CodeMaster Defibrillator/Monitors — XL+ (M1722A/B) XL (M1723A/B) Service Manual

Printed in USA
HP Part Number: M1722-91909
Print Date: August 1996
Edition 5
E0896

Notice

The information in this document may change without notice.

Hewlett-Packard makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Hewlett-Packard shall not be liable for errors herein or for incidental or consequential damages in connection with the furnishing, performance or use of this material.

This document contains or refers to proprietary information which is protected by copyright. All rights are reserved. Copying or other reproduction of this document without prior written permission of Hewlett-Packard Company is prohibited.

Responsibility of the Manufacturer

Hewlett-Packard only considers itself responsible for any effects on safety, reliability, and performance of the equipment if:

- Assembly operations, extensions, re-adjustments, modifications or repairs are done by persons authorized by Hewlett-Packard, and
- The electrical installation of the relevant room complies with the IEC requirements (IEC regulated countries only), and
- The instrument is used according to the instructions for use presented in this manual.

Warranty

Hewlett-Packard (HP) warrants this medical product against defects in materials and workmanship for a period of:

1 One (1) year on instrument, except in U.S. and Canada—five (5) years.

2 One (1) year on main battery.

3 All other accessories including cables and consumables are under standard, 90 day warranty.

If HP receives notice of such defects during the warranty period, HP shall, at its option, either repair or replace hardware products which prove to be defective.

HP software and firmware products which are designated by HP for use with a hardware product, when properly installed on that hardware product, are warranted not to fail to execute their programming instructions due to defects during the warranty period. HP shall repair or replace software media and

Introduction

This chapter introduces the CodeMaster XL+ (HP M1722A/B) and XL (HP M1723A/B) Defibrillator/Monitor and lists technical specifications.

WARNING

Dangerous voltages capable of causing injury or death are present at the paddles or patient cables during normal operation. This defibrillator is to be used and serviced only by qualified personnel.

CAUTION

Operation of this device in the vicinity of high-powered transmitters or electrosurgical instruments may result in interference of the ECG display.

NOTE

Safe and effective use of medical instrumentation requires periodic inspection and preventive maintenance. Perform the preventive maintenance procedures in Chapter 3, **Performance Verification and Maintenance**, of this manual at the required intervals to ensure satisfactory instrument performance.

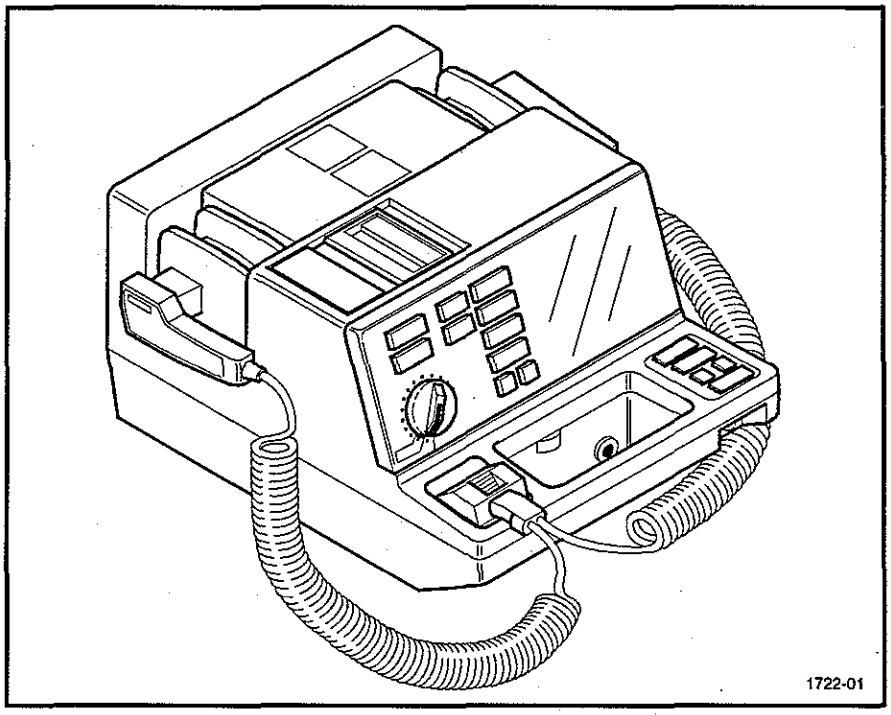
The CodeMaster XL+ and XL Defibrillator/Monitor

These instruments are portable defibrillator/monitors powered by internal battery or AC power. They combine a 360-joule defibrillator, ECG monitor, and annotating strip chart recorder in a compact, light-weight package. Instrument features include crisis-oriented controls, fast charge, a real-time clock, interchangeable paddles, and automatic documentation of events. The monitor includes a 5-inch screen which displays the ECG, selected ECG source, heart rate, and messages and alerts. A microprocessor-based system rejects noise and artifact, and automatically stabilizes and restores baseline.

In addition, the XL+ model has adjustable heart rate alarms, patient contact indicator (PCI), recorder event marker, complete recorder annotation, event summary, and 3- and 5-wire patient cable ECG capability. Transcutaneous external pacing is available as an option or field upgrade for the XL+; another option is a 12-pin ECG input connector that is compatible with the ECG patient cable. The XL+ can interface to the HP Central Station via an analog-only high-level ECG Out signal. Figure 1-1 shows the XL+ defibrillator.

Both models fit onto the MTRO-OO336L cart. The cart features three drawers (with a latch/lock system) for storing suction pumps and other resuscitation equipment.

Figure 1-1



CodeMaster XL+ Defibrillator/Monitor

The defibrillators are designed for long-term reliability. The modular design makes extensive use of VLSI and gate-array technology. The modular approach means less downtime for the user, due to the quick field repair times inherent in the subassembly replacement philosophy of repair. The built-in menu-driven tests efficiently aid in identifying faulty operation, further speeding the repair process.

MTRO-00336L Cart

The MTRO-00336L Cart provides mobility for the CodeMaster defibrillators. The cart shell and drawers are constructed of a durable light-weight polymer material that will not corrode, rust, or dent. Built-in hand grips and 5-inch non-marring casters (two with brakes) provide easy maneuverability. The cart surfaces are smooth and stain-resistant, with rounded corners. Drawers can be removed without tools for thorough cleaning.

Inquiries

For questions or comments regarding these instruments, contact the nearest HP Sales/Service Office or to one of HP's Service Dispatch Centers. Always identify the instrument by model number and serial number in all correspondence. Hewlett-Packard sales and service offices are listed at the end of this manual. Toll-free numbers for Service Dispatch Centers are listed in Chapter 7, **Parts Lists**.

Specification Data

The following tables list the technical specifications for the defibrillators and the mobile cart. Specifications are the same for both models except where pointed out as being different.

Table 1-1 **Physical Specifications**

Parameter	Specification
Dimensions (l × w × h)	
defibrillator:	15.75" × 12.75" × 8.0" (40.05 cm × 32.39 cm × 20.32 cm)
cart:	22" × 34" × 34.5" (55.9 cm × 86.3 cm × 87.6 cm)
Weight	
defibrillator:	24 lbs. (10 kg) (includes external paddles, battery, and recorder paper.)
cart:	82 lbs. (37 kg)
Chemical resistance, cleaners:	Withstands the following: isopropyl alcohol (except leadwires and patient cable), mild soap and water, chlorine bleach and water (30 ml/l of water).

CAUTION The main battery will be damaged if stored for extended periods at a temperature greater than 50° C

Table 1-2 Environmental Specifications

Parameter	Specification
Temperature	
operating:	0° to 55° C (32° to 131° F)[1]
storage:	–20° to 70° C (–4° to 158° F)[1]
Humidity	
operating:	15 to 95% RH, non-condensing
storage:	15 to 95% RH, non-condensing
Pressure (altitude)	
operating:	To 15,000 ft. (4600 m)
storage:	To 15,000 ft. (4600 m)

[1]Battery must be removed below 0° C (32° F) and above 45° C (113° F).

Table 1-3 Electrical Specifications

Parameter	Specification
Defibrillator	
Output energy (delivered):	2, 3, 5J (±1J)
	7, 10J (±2J)
	20, 30J (±4J)
	50, 70, 100, 150, 200, 300, and 360J (±15%)
Waveform:	Damped sinusoidal (Lown).
Charge control:	Push-button on apex paddle and on front panel.
Charge time (Battery operation):	Less than 5 seconds to 360 joules.
Armed indicators:	Charge done tone, charge done lamp on apex paddle, and available energy indicated on display.
Paddle contact indicator (PCI): (XL+ only)	3-color LED bar graph array on STERNUM paddle indicates quality of defibrillator paddle contact before discharge.
Paddles:	Standard paddles are anterior/anterior, adult and pediatric. Adult electrodes (83 cm sq) slide off to expose pediatric electrodes (21 cm sq). Paddle cord is 10 ft (3m). Full range of internal paddles are available.

Table 1-3 Electrical Specifications (Continued)

Parameter	Specification
Synchronizer:	SYNC message appears on monitor and is annotated periodically on recorder while in synchronous mode. An audible beep sounds with each detected R- wave, while a marker on the monitor and sync designator on the recorder strip indicate the discharge point.
Monitor	
Inputs:	ECG may be viewed through paddles or patient cable. Lead I, II, III, or PADDLES selectable. Additional leads (avR, avF, AvL, V Leads) and PADS are available (XL+ only). Monitor and recorder indicate selected ECG source.
Lead fault:	LEADS OFF message and dashed baseline appear on monitor if a lead becomes disconnected.
Common mode rejection:	Leads: ≥100 dB and Paddles: ≥90 dB measured as per AAMI standards for cardiac monitors (EC13).
Pace pulse rejection:	The pace pulse rejection algorithm of this product meets the requirements of Section 3.1.4.1 (Pacemaker Pulse Rejection Without Over/Undershoot) of AAMI EC13 - 1983 (Cardiac Monitors, Heart Rate Meters and Alarms). This product will not reject pace pulses as described in Section 3.1.4.2 (Pacemaker Pulse Rejection With Over/Undershoot) of the same document.
Display size and type:	5 inch diagonal (12.7 cm) CRT for 4 seconds of ECG data on screen; non-fade, fixed trace. Scrolling trace is selectable.
Sweep speed:	25 mm/sec nominal.
Frequency response:	0.5 to 40 Hz.
Heart rate display:	Digital readout on monitor from 15 to 350 BPM.
Heart rate alarms:	Three pairs of high and low heart rate alarm limits from 20 to 280 BPM. On XL+, limits are configurable.
ECG output:	1 V/mV.
Patient cable length:	10 ft.
Thermal Array Recorder	
Event summary: (XL+ only)	Stores and prints 3 seconds of pre-critical event data, and 8 seconds of post-critical event data for up to 28 events. Data is retained after unit is turned off.
Annotates:	Time, date, HR, ECG mode, event marker, defibrillator mode, and selected energy. Additionally, on XL+, actual delivered energy, peak current, and patient impedance.
Speed:	25 mm/sec.
Paper size:	50 mm by 30 m (100 ft).
Recorder mode:	May be configured to automatically document events and ECG during defibrillation episodes. The recorder can be configured to run in either real time or with a 6 second delay.
Frequency response:	0.5 to 40 Hz. Additionally, on XL+, 0.05–150 Hz selectable.

Table 1-4 Power and Battery Specifications

Parameter	Specification
AC Line Power	
Line frequency:	50 and 60 Hz.
Line voltage:	100–230 V AC ±15%.
Battery	
Type:	Rechargeable sealed lead-acid. 4 Ah, 12 V nominal.
Charge time:	Approximately 2 hours to 90% of full capacity. 18 hours to 100% capacity. Repeated charging to less than 100% will reduce useful life of battery.
Capacity:	Approximately 2.5 hours of monitoring, or 50 full-energy discharges, or 1 hour of monitoring and recording.
Indicators:	Illuminated LED indicates battery is charging. LOW BATTERY message appears on monitor when limited battery capacity remains.

Table 1-5 External Pacer (Optional—XL+ only)

Parameter	Specification
Current pulse amplitude:	30 mA to 200 mA.
Pulse width:	20 msec.
Rate:	40 ppm to 180 ppm.
Modes:	Demand or fixed rate.
Refractory period:	40 to ≤80 ppm: 340 msec ± 10%; >80 to 180 ppm: 240 msec ± 10%.

Table 1-6

SpO_2 Monitor (Optional)

Parameter	Specification
SpO_2 measurement	Range: 0 to 100% Accuracy with HP 1190A transducer: 1 standard deviation. 65% to 80%: ±2.5% 80% to 100%: ±1.5% Accuracy with Nellcor N-25, I-20, D-20, D-25, Oxiband A/N, Oxiband P/I sensors: 1 standard deviation. 80% to 100%: ±3%
Pulse rate measurement	Range: 30 to 300 bpm. Accuracy: ±1% Resolution: 1bpm
Averaging	SpO_2 and pulse rate: averaged over eight beats.
SpO_2 alarm limits	Three preset limits: 100/90, 100/85, and 100/80. Default is alarms off.
Time to alarm	Alarm within 10 seconds of SpO_2 value dropping below alarm setting.
Time to valid numeric	Valid 15 seconds after power on.
Recovery after defibrillation	Valid numeric 15 seconds after a discharge
INOP alerts	Warning messages for: SpO_2 cable off noisy signal low signal light interference
Pulse amplitude indicator	Indicates pulsatile activity.

Table 1-7

Shock Advisory (Optional)

Parameter	Specifications
Analysis Time	seven to ten seconds
Output Energy (Delivered)	Factory default protocol 200J, 200J, 360J
Analysis Control	Push-button on front panel
Charge Time	Less than 5 secons to 360 joules with battery present. Less than 15 seconds to 360 joules to AC only.
Armed Indicators	Charge done tone and available energy indicated on display
Advisory Event Summary	Stores approximately 200 events and 50 ECG strips. Data retained after instrument turned off.
Waveform:	Damped sinusoidal (Lown)

Options and Accessories

CodeMaster XL+ and XL Defibrillator/Monitor

These tables list the options and accessories available for the XL+ and XL defibrillators. Option and accessory information applies to both models unless otherwise noted.

Country Options

Each country option includes appropriate power cord, and language. Table 1-8 shows the configuration of each country option.

Table 1-8 Country Option Configurations

Option	Country	Labels	Users Manuals[1]	Voltage[2]	Frequency[2]	Power Cord[3]
ABA	North America	English	English	120	60	903-US, NEMA 5-15
ABB	Europe	English	English	220	50	902-EURO, IEC 83
ABC	Canada	French	French	120	60	903-US, NEMA 5-15
ABD	Germany	German	German	220	50	902-EURO, IEC 83
ABE	Spain	Spanish	Spanish	220	50	902-EURO, IEC 83
ABF	France	French	French	220	50	902-EURO, IEC 83
ABG	Australia	English	English	240	50	901-Australia
ABH	Netherlands	Dutch	Dutch	220	50	902-EURO, IEC 83
ABJ	Japan	Japanese	Japanese	100	50	903-US, NEMA 5-15
ABK	Intercon English	English	English	220	50	902-EURO, IEC 83
ABL	Canada	English	English	120	60	903-US, NEMA 5-15
ABM	Latin America	Spanish	Spanish	120	60	903-US, NEMA 5-15
ABN	Norway	Norwegian	Norwegian	220	50	902-EURO, IEC 83
ABP	Switzerland	German	German	220	50	906-Swiss
ABQ	Switzerland	French	French	220	50	906-Swiss
ABS	Sweden	Swedish	Swedish	220	50	902-EURO, IEC 83
ABU	United Kingdom	English	English	240	50	900-UK, BS 1363 A
ABX	Finland	Finnish	Finnish	220	50	902-EURO, IEC 83
ABY	Denmark	Danish	Danish	220	50	912-Danish
ABZ	Italy	Italian	Italian	220	50	902-EURO, IEC 83

Table 1-8 Country Option Configurations (Continued)

Option	Country	Labels	Users Manuals[1]	Voltage[2]	Frequency[2]	Power Cord[3]
ACD	Switzerland	English	English	220	50	906-Swiss
ACQ	South Africa	English	English	240	50	917-EURO, IEC 83
ACS	Europe	French	French	220	50	902-EURO, IEC 83
AKL	Thailand	English	English	220	50	903-ULS, NEMA 5-15
AKM	China	English	English	220	50	901-China
AKV	South America	Spanish	Spanish	220	50	902-EURO, IEC 83

[1]See Table 1-9 and Table 1-10 for HP part numbers.
[2]CodeMaster AC input: 100 to 230 VAC, ±15%, 50 to 60 Hz.
[3]See Table 1-11 for HP part numbers.

Table 1-9 Codemaster XL+ (M1722A/B) Documentation Part Numbers

Country	User Guide Part Number	User Card Part Number	Pacer Card Part Number	Checkcard Part Number	SpO_2 Concept Guide	SpO_2 Sensor Guide
English	M1722-91908	M1722-92908	M1722-93900	M1722-93920	M1722-93950	M1722-93970
French	M1722-91918	M1722-92918	M1722-93901	M1722-93921	M1722-93951	M1722-93971
German	M1722-91928	M1722-92928	M1722-93902	M1722-93922	M1722-93952	M1722-93972
Dutch	M1722-91938	M1722-92938	M1722-93903	M1722-93923	M1722-93953	M1722-93973
Spanish	M1722-91948	M1722-92948	M1722-93904	M1722-93924	M1722-93954	M1722-93974
Italian	M1722-91958	M1722-92958	M1722-93905	M1722-93925	M1722-93955	M1722-93975
Swedish	M1722-91968	M1722-92968	M1722-93906	M1722-93926	M1722-93956	M1722-93976
Japanese	M1722-91978	M1722-92978	M1722-93907	M1722-93927	M1722-93957	M1722-93977
Norwegian	M1722-91919	M1722-92919	M1722-93908	M1722-93928	M1722-93958	M1722-93978
Finnish	M1722-91920	M1722-92920	M1722-93909	M1722-93929	M1722-93959	M1722-93979
Danish	M1722-91921	M1722-92921	M1722-93910	M1722-93930	M1722-93960	M1722-93980

Table 1-10 Codemaster XL (M1723A/B) Documentation Part Numbers

Country	User Guide Part Number	User Card Part Number	Checkcard Part Number	SpO_2 Concept Guide	SpO_2 Sensor Guide
English	M1723-91908	M1722-92908	M1722-93920	M1722-93950	M1722-93970
French	M1723-91918	M1722-92918	M1722-93921	M1722-93951	M1722-93971
German	M1723-91928	M1722-92928	M1722-93922	M1722-93952	M1722-93972
Dutch	M1723-91938	M1722-92938	M1722-93923	M1722-93953	M1722-93973
Spanish	M1723-91948	M1722-92948	M1722-93924	M1722-93954	M1722-93974
Italian	M1723-91958	M1722-92958	M1722-93925	M1722-93955	M1722-93975
Swedish	M1723-91968	M1722-92968	M1722-93926	M1722-93956	M1722-93976
Japanese	M1723-91978	M1722-92978	M1722-93927	M1722-93957	M1722-93977
Norwegian	M1723-91919	M1722-92919	M1722-93928	M1722-93958	M1722-93978
Finnish	M1723-91920	M1722-92920	M1722-93929	M1722-93959	M1722-93979
Danish	M1723-91921	M1722-92921	M1722-93930	M1722-93960	M1722-93980

Table 1-11 **CodeMaster XL/XL+ (M1722A/B & M1723A/B) Shock Advisory Documentation**

Country	User's Guide Part Number	Concept Guide Part Number
English	M1722-94960	M1722-94940
French	M1722-94961	M1722-94941
German	M1722-94962	M1722-94942
Dutch	M1722-94963	M1722-94943
Spanish	M1722-94964	M1722-94944
Italian	M1722-94965	M1722-94945
Swedish	M1722-94966	M1722-94946
Japanese	M1722-94967	M1722-94947
Norwegian	M1722-94968	M1722-94948
Finnish	M1722-94969	M1722-94949
Danish	M1722-94970	M1722-94950

Table 1-12 **Power Cord Part Numbers**

Power Cord Key	HP Part Number
900	8120-1351
901	8120-1369
902	8120-1689
903	8120-1378
906	8120-2104
912	8120-3997
917	8120-4211

Pacer Option—CodeMaster XL+ only

C02	Add Pacer—English
C03	Add Pacer—French
C04	Add Pacer—German
C05	Add Pacer—Dutch
C06	Add Pacer—Spanish
C07	Add Pacer—Italian
C08	Add Pacer—Swedish
C09	Add Pacer—Japanese
C10	Add Pacer—Norwegian
C11	Add Pacer—Finnish
C12	Add Pacer—Danish

SpO_2 Option

C62	Add SpO_2—English
C63	Add SpO_2—French
C64	Add SpO_2—German
C65	Add SpO_2—Dutch
C66	Add SpO_2—Spanish
C67	Add SpO_2—Italian
C68	Add SpO_2—Swedish
C69	Add SpO_2—Japanese
C70	Add SpO_2—Norwegian
C71	Add SpO_2—Finnish
C72	Add SpO_2—Danish
C73	SpO_2 adult finger tip sensor, reusable (M1190A)
C74	Adaptor cable for Nellcor sensors (M1900B)

Paddles and Pad Options

C13	Delete Standard Ant/Ant Paddles
C14	Add Internal Paddle Adapter Cable
C15	Add 7.5 cm Internal Paddles (switchless)
C16	Add 6.0 cm Internal Paddles (switchless)
C17	Add 4.5 cm Internal Paddles (switchless)
C18	Add 2.8 cm Internal Paddles (switchless)
C26	Add 7.5 cm Internal Paddles (switched)
C27	Add 6.0 cm Internal Paddles (switched)
C28	Add 4.5 cm Internal Paddles (switched)
C29	Add 2.8 cm Internal Paddles (switched)
C20	Add Adhesive Pads Adapter
C21	Add Adhesive Pads

ECG Cable/Connector Options

C30	Substitute 6-pin AAMI ECG connector; includes 6-pin 3-wire AHA cable
C31	Substitute 6-pin AAMI ECG connector; includes 6-pin 5-wire AHA cable (XL+ only)
C32	Substitute 12-pin HP CMS ECG connector; includes 12-pin 3-wire AHA cable
C33	Substitute 12-pin HP CMS ECG connector; includes 12-pin 5-wire AHA cable (XL+ only)
C34	Substitute 12-pin HP CMS ECG connector; includes 12-pin 3-wire IEC cable
C35	Substitute 12-pin HP CMS ECG connector; includes 12-pin 5-wire IEC cable (XL+ only)
C36	Substitute 8-pin 5-wire AHA ECG cable (XL+ only)
C37	Substitute 8-pin 5-wire IEC ECG cable (XL+ only)

Hardware Options

C50	Add Swivel Wall-Mount Hardware
C51	Add Carrying Case
C52	Add Accessory Pouch

Sync Cable Options

J01	Add 8-pin Sync Cable
J02	Add 6-pin AAMI Sync Cable
J03	Add 12-pin HP CMS Sync Cable

Documentation Options

0B3	Service Manual (English only)
0BP	In-Service Training Video (VHS-NTSC)
0BQ	In-Service Training Video (VHS-PAL)
0BR	Service Training Video (VHS-NTSC)
0BS	Service Training Video (VHS-PAL)

Standard Accessories Supplied

- ❑ *CodeMaster XL+ Users Guide* (M1722A/B only)
- ❑ *CodeMaster XL Users Guide* (M1723A/B only)
- ❑ *CodeMaster XL Series Quick Reference Card* (M1722A/B and M1723A/B)
- ❑ ECG Patient Cable (language/country specific)—HP M1733A
- ❑ Disposable Electrodes—HP 14445C
- ❑ 1 roll, Thermal Paper—HP 40457C
- ❑ 1 tube Redux® Creme—HP 651-1008-010

Cart

MTRO-00336L	Add Cart

Installation and Configuration

Introduction

This chapter covers installing and configuring the CodeMaster XL+ or XL Defibrillator/Monitor. If you are a Hewlett-Packard service representative, this information provides a factory-recommended process to use when assisting customers. The configuration information guides you through the setup menus, and describes configuration choices.

Installation

The defibrillator is ready for operation when the following tasks have been properly performed:

- ❑ Install battery.
- ❑ Charge battery (for 24 hours).
- ❑ Install paper.
- ❑ Make sure that the paddle set connector is seated and locked.
- ❑ Select configuration settings; set date and time.

Line Voltage Settings

The defibrillator automatically adjusts to the line voltage that is supplied (from 100–230 VAC ±15% at 50/60 Hz). No manual setting or adjustment is required.

Installing and Charging the Battery

This procedure describes installing the battery for the first time. To replace a battery, refer to the battery replacement procedure in Chapter 6, **Removal and Replacement.**

NOTE

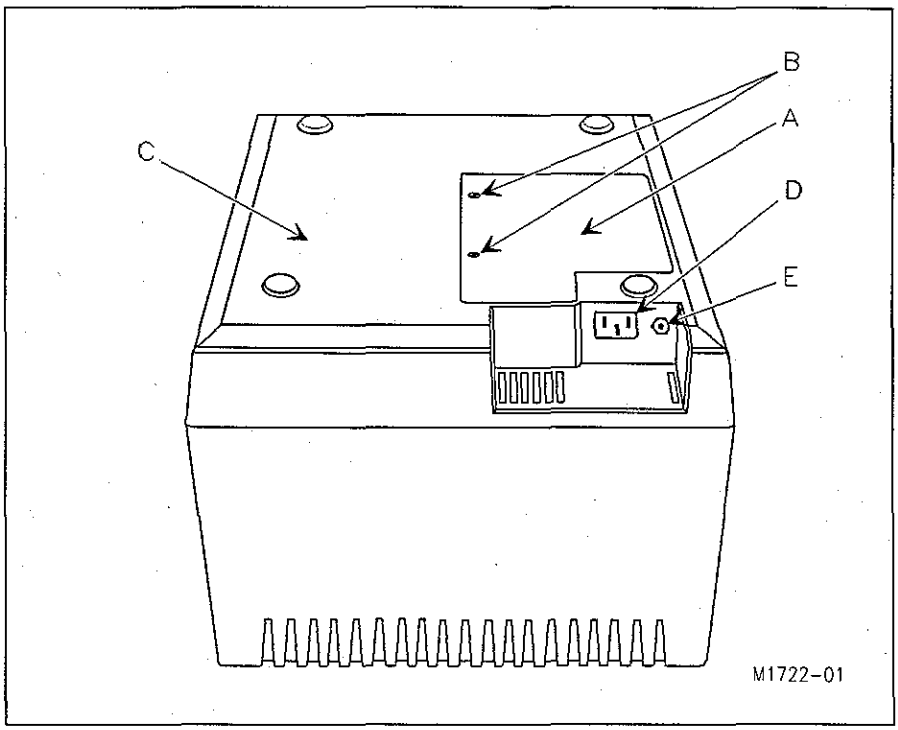
The defibrillator operates from either battery or AC power.

Use only HP battery assembly M1758A.

WARNING

To avoid the possibility of hazardous electrical shock, unplug the instrument from the AC power source before installing or replacing the battery.

Figure 2-1



Accessing the Battery Compartment

A Battery compartment door.

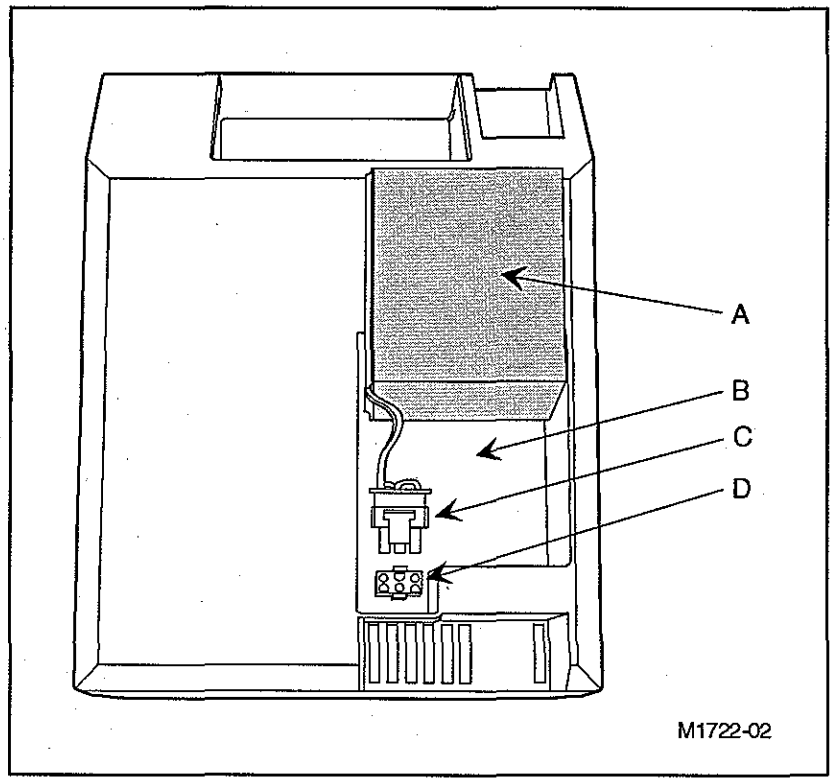
B Retaining screws ($\frac{1}{4}$ turn).

C Bottom side of defibrillator.

D AC power receptacle.

E Equipotential connector.

Figure 2-2



Installing the Battery

A Battery.

B Battery compartment.

C Battery plug.

D Battery connector.

To install the battery:

1 Turn the instrument upside down.

2 Open the defibrillator battery compartment by turning the two $\frac{1}{4}$-turn screws on the battery door $\frac{1}{4}$ turn counter clockwise (as shown in Figure 2-1); then, lift off the battery door.

3 Align the polarized battery plug with the battery connector located inside the battery compartment (as shown in Figure 2-2). Be sure to match the keying.

4 Push the plug into the connector until the plug is locked.

5 Gently lower the battery into the battery compartment until completely seated.

6 Route the battery cable between the battery and the compartment wall, so the cable will not be caught between the compartment door and the case.

7 Replace the battery door and secure it by turning the two retaining screws $\frac{1}{4}$ turn, clockwise.

8 Turn the instrument right side up.

9 Connect the power cord to the defibrillator, then plug the cord into an AC outlet. The green (AC POWER) and (BATT CHRG) indicators on the front panel should light up. (The (AC POWER) indicator lights when the instrument is plugged into AC power; the (BATT CHRG) indicator is on when the battery is installed *and* the instrument is plugged into AC power.)

NOTE

To ensure full battery capacity, charge the battery for 24 hours following its installation in the defibrillator.

CAUTION

If the defibrillator will be stored for longer than one month without AC power, remove the battery from the unit. Note on the instrument that the battery has been removed. After an extended storage period, the battery should be tested using the battery capacity check. See Chapter 3, **Performance Verification and Maintenance**.

Loading the Recorder Paper

The defibrillator recorder uses two-inch wide, thermal paper (HP 40457C/D). To load the paper:

1 Slide the recorder door toward the right side of the defibrillator until the paper platen tilts up.

2 Pull up on the plastic removal tag to remove the old paper roll, if one is present.

3 Unroll about six inches of paper on the new roll; turn the paper roll so that the grid side of the unrolled paper is on the bottom (facing downward).

4 Place the roll of thermal paper in the recorder so that the grid side of the paper will face the print head in the recorder.

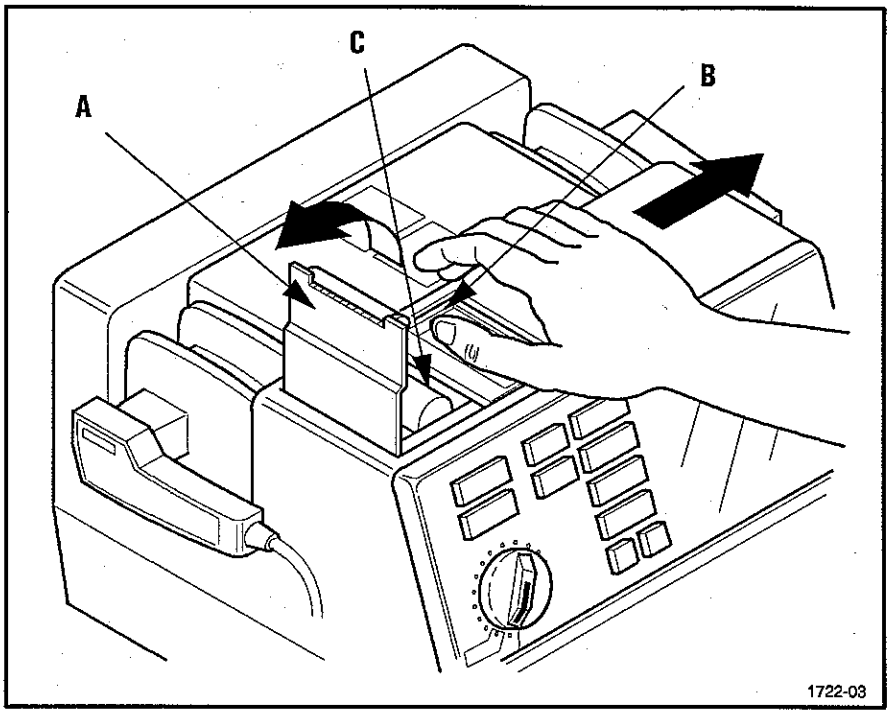
5 Pull the free end of the paper upward and over the recorder platen. (See Figure 2-3).

6 While holding the recorder door open (to the right), press the platen down to its normal (closed) position.

7 Release the recorder door, allowing it to close over the platen.

8 Place the free end of the paper on the left side of the recorder. The grid side should be visible (facing up).

Figure 2-3



Loading the Paper

A Recorder Door.

B Paper Platen.

C Paper.

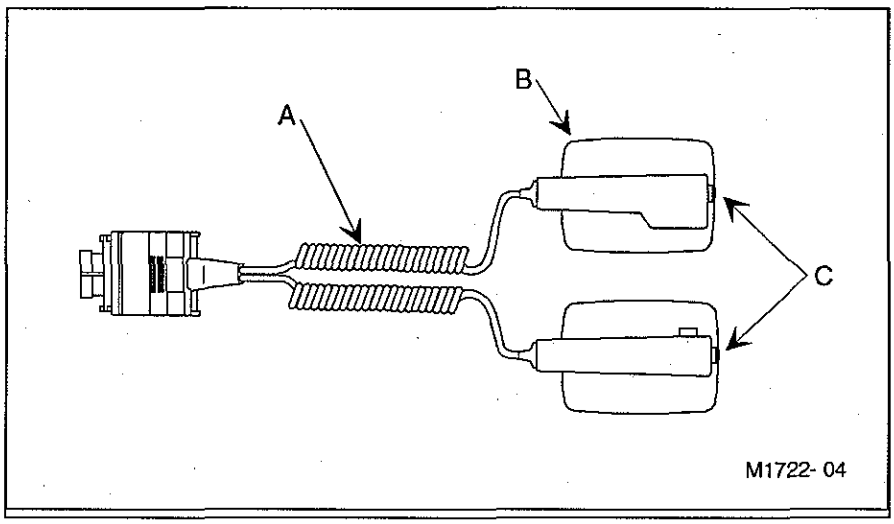
Connecting Paddles, Patient Cables and SpO_2 sensors

The defibrillator has a paddles connector (defibrillator connector) for attaching pads/paddles sets and the ECG Input connector for attaching leads. It also has an optional SpO_2 connector for attaching SpO_2 sensors.

Defibrillator Connector

The defibrillator connector accepts external paddles, external adhesive pads, or internal paddles. The next three figures show these paddles and pads.

Figure 2-4



External Paddle Set

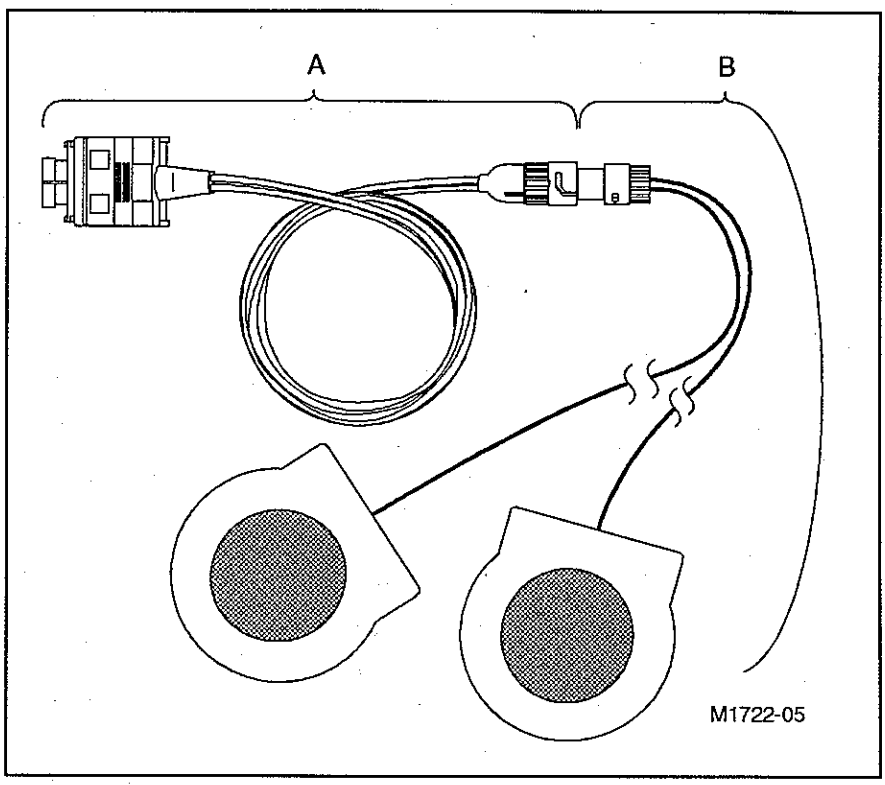
A Adult/Pediatric Anterior/Anterior paddle set.

B Standard external (adult) paddle.

C Adult adaptor release latch.

The standard external paddles set also includes pediatric paddles. To expose the pediatric paddle set, depress the release latch at the front of a paddle while pulling forward on the adult paddle surface. This will remove the adult paddle contact surface and uncover the smaller pediatric contact surface.

Figure 2-5

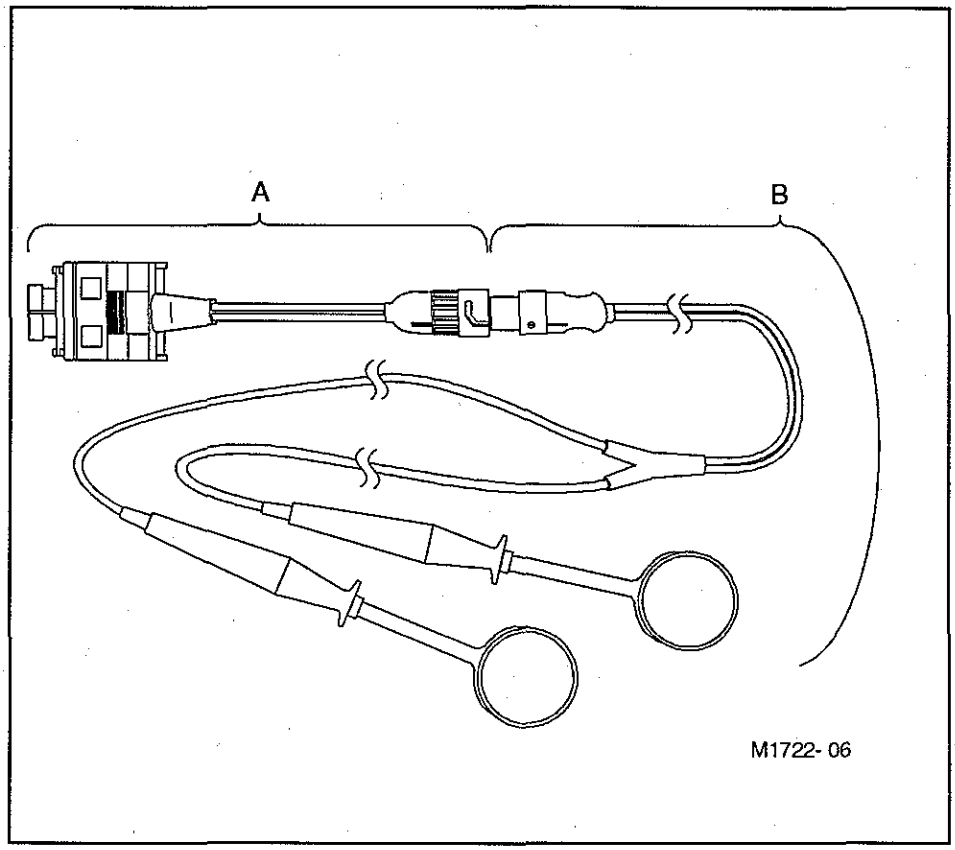


Pads Adapter Cable and External Adhesive Pads

A Pads adapter cable—9 ft. in length (HP M1750A/B). This cable is not compatible with the internal paddles set shown in Figure 2-6.

B External adhesive pads.

Figure 2-6



Internal Paddles

A Internal paddles adapter cable—1 ft. in length.

B Internal paddle set.

Table 2-1 lists the paddles sets, adapter cables, and their part numbers.

Table 2-1 **Paddles/Pads Sets, Adapter Cables for Defibrillator Connector**

Description	P/N[1]	Application[2]
EXTERNAL PADDLES:		D, S, M
Integrated cable/paddles set (Standard with instrument)		
CodeMaster XL+ (with PCI):	M1746A/B	
CodeMaster XL (without PCI):	M1747A/B	
INTERNAL PADDLES		D
Internal paddles adapter cable:	M1740A/B	
Switchless internal paddle set		
7.5 cm:	M1741A	
6.0 cm:	M1742A	
4.5 cm:	M1743A	
2.8 cm:	M1744A	
Switched internal paddle set		
7.5 cm:	M1784A	
6.0 cm:	M1785A	
4.5 cm:	M1786A	
2.8 cm:	M1787A	
EXTERNAL ADHESIVE PADS		D, S, M, P
Pads adapter cable:	M1750A/B	
Adult multifunction pads (AAMI):	M1749A	
Adult multifunction pads (IEC):	M1749B	
Pediatric multifunction pads (IEC);	M1749C	
Pediatric multifunction pads (AAMI);	M1749D	

[1]Parts numbered with an **A** and **B** suffix are identical except that a part ordered with the **B** suffix is **yellow**.

[2]Application key: D = Defibrillation, S = Synchronized cardioversion, M = Monitoring, P = Pacing.

You may configure the instrument to make PADDLES (PADS) the default monitoring source at power-on. This choice is available in setup menu 2. See "Configuration" on page 2-17.

Connecting Paddles or Pads. To connect external paddles, internal paddles, or adhesive pads to the defibrillator, perform the following steps:

1 Slide the paddle connector lock on the paddles plug to the **unlock** position. To do this, push the lock in the direction shown by the arrow in Figure 2-7.

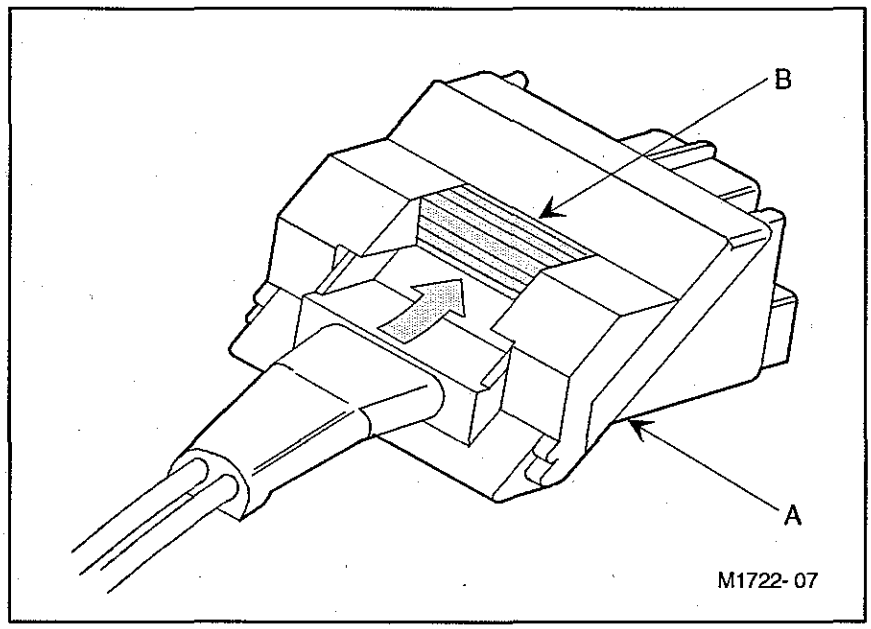
2 Insert the paddles/pads adapter cable plug into the paddles connector on the defibrillator, as shown in Figure 2-8.

CAUTION

Do not insert the plug into the connector without unlocking the connector lock (see step 1). If you do not unlock the connector lock before inserting the plug, the locking mechanism may be disengaged.

3 Slide the paddle connector lock to the **lock** position, to latch the plug in place.

Figure 2-7

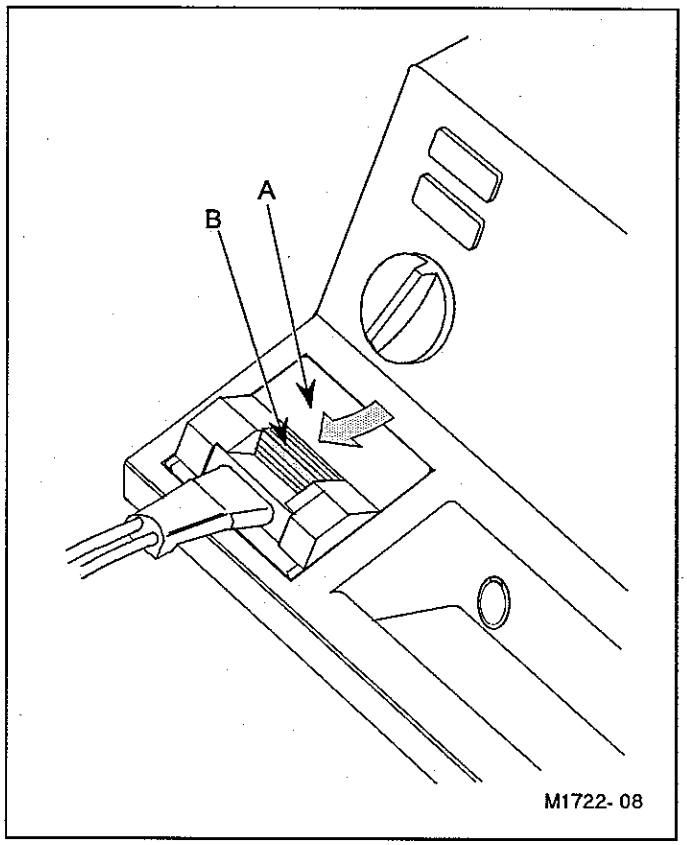


Opening Lock

A Paddles Plug.

B Connector Lock. Push the lock in the direction indicated by the arrow to move the lock to the **unlock** position (shown).

Figure 2-8



Connecting External Paddles, Adhesive Pads, or Internal Paddles

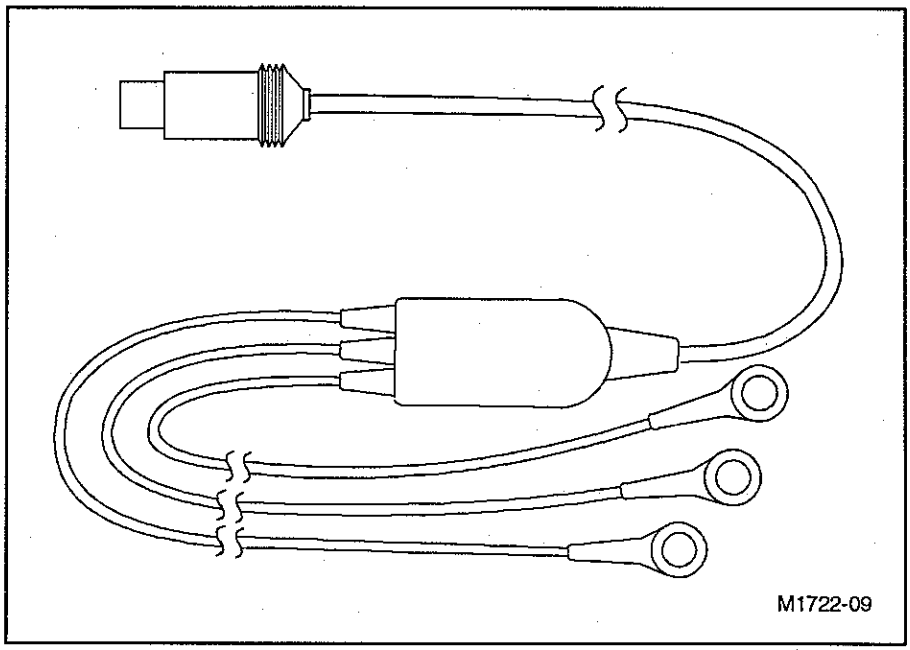
A Paddles Plug in Paddles Connector.

B Connector Lock. Push the lock in the direction indicated by the arrow to move the lock to the **lock** position (shown).

ECG Input Connector

The ECG Input connector on the defibrillator is a 6-, 8-, or 12-pin connector, depending on the option purchased with the instrument. For each connector option, several different patient cables can be used for various ECG sources and applications. Figure 2-9 shows an example of a patient cable.

Figure 2-9



An ECG Patient Cable

Table 2-2 lists available patient cables and lead sets, and their part numbers.

Table 2-2 Patient Cables and Lead Sets

Patient Cables, Leads, Lead Sets	Part Number
6-Pin Patient Cables (AHA only)	
3-wire	M1731A
5-wire	M1732A
8-Pin Patient Cables	
AHA 3-wire	M1733A
AHA 5-wire	M1734A
IEC 3-wire	M1735A
IEC 5-wire	M1736A
12-Pin Patient Cables (a trunk cable and a matching lead set)	Trunk Cable/Lead Set Part Number
AHA 3-wire	M1500A/M1605A
AHA 5-wire	M1520A/M1625A
IEC 3-wire	M1510A/M1615A
IEC 5-wire	M1530A/M1635A

NOTE

3 wire = RA, LA, LL
5 wire = RA, RL, LA, LL + V (C)

Connecting a Patient Cable . The 3-wire or 5-wire patient cable connects to the ECG Input connector located on the front of the defibrillator, behind the carrying handle. The patient cable plug has 6- , 8-, or 12-pins. Before installing the patient cable, make sure that the pin count of the patient cable plug matches the pin count of the ECG Input connector. To install the patient cable:

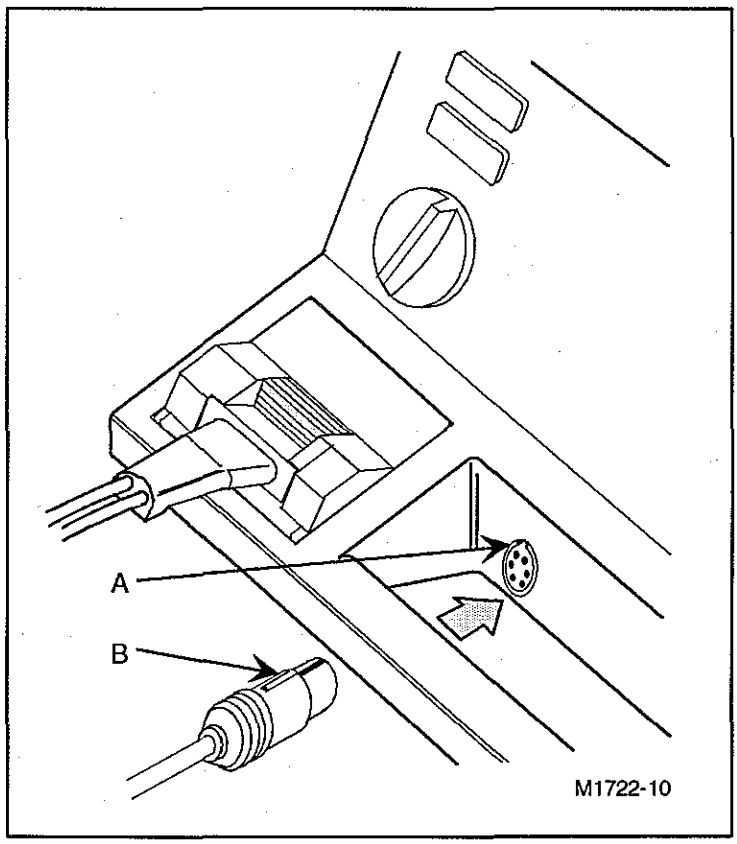
1 Align the keyed cable plug with the slot in the ECG Input connector. See Figure 2-10.

2 Push the cable plug firmly into the ECG Input connector.

NOTE

When a lead is selected for monitoring, the message `LEADS OFF` appears on the display if the patient cable falls off or is incorrectly connected. Also, a dashed line appears on the display in place of an ECG trace.

Figure 2-10



Connecting a Patient Cable

A ECG Input connector with key slot.

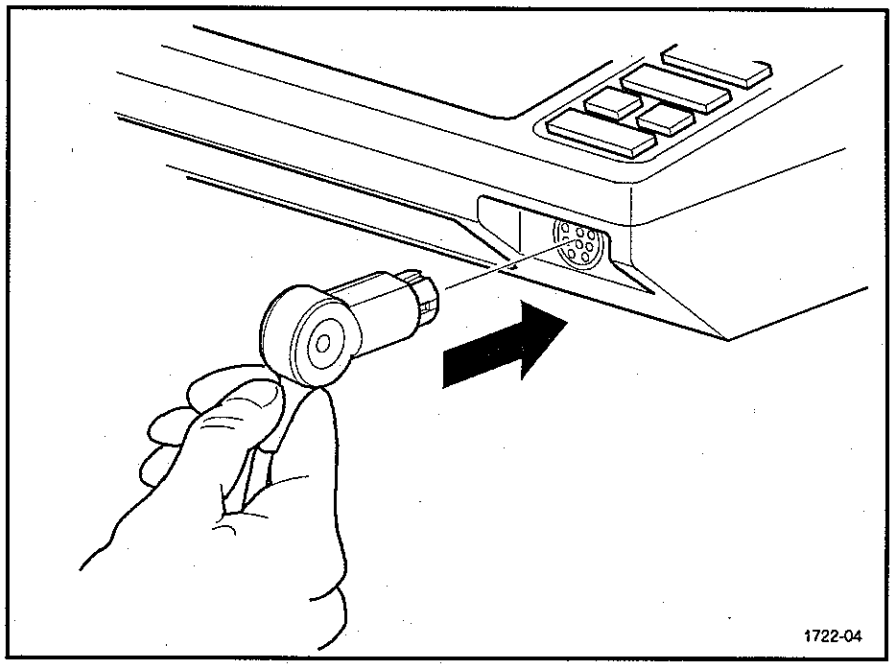
B Keyed plug of patient cable.

SpO_2 Connector

You can attach the HP M1190A SpO_2 sensor or the HP M1900B adaptor cable to the SpO_2 connector. Refer to the *Sensor Guide* (HP M1722-93970) for available sensors.

Connecting an SpO_2 Sensor. The HP M1190A SpO_2 sensor and the HP M1900B adaptor cable attach to the SpO_2 connector on the front of the defibrillator to the right of the carrying handle. The connector and the end of the cable are color-coded blue. To connect the cable, align the keyed cable plug with the slot on the connector as shown in Figure 2-11, and push the plug firmly into the connector.

Figure 2-11



Connecting an SpO_2 Sensor

Configuration

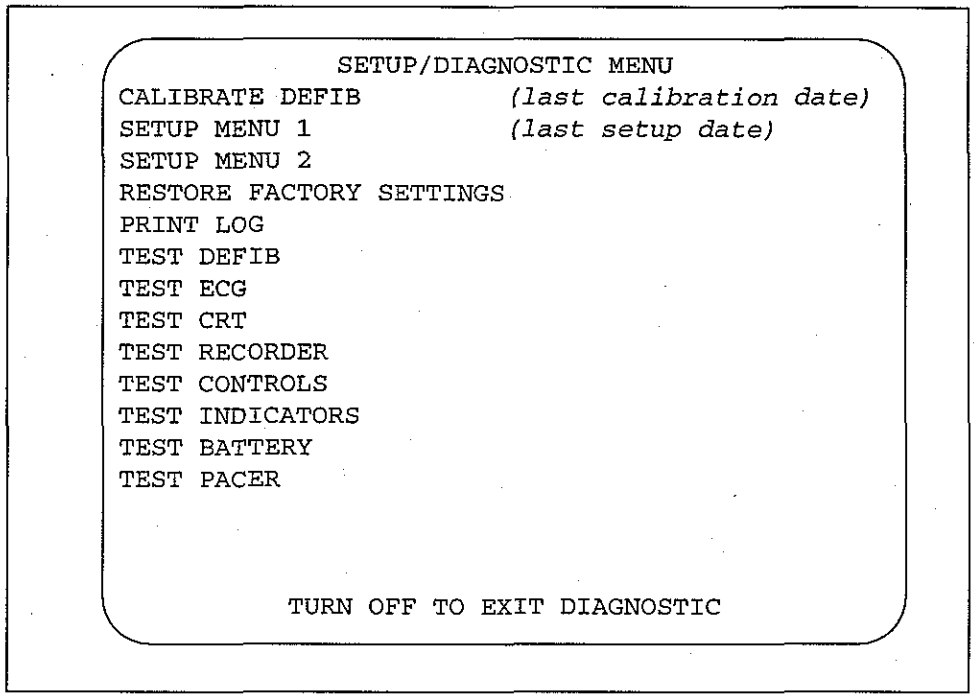
The defibrillator is designed to provide custom operation. Configuration settings let the user program the defibrillator for the most useful and efficient operation. Defibrillator configuration is set at the factory, but should be checked by the technician at initial installation and changed, as desired.

This section describes how to display, print, or change the defibrillator configuration settings and the current date and time.

Displaying the Setup/Diagnostic Menu

To display the setup/diagnostic menu, press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from the **Off (Standby)** to **Monitor On** position. A display with a list of choices appears. Figure 2-12 shows the items on the menu.

Figure 2-12



Setup/Diagnostic Menu

NOTE

The pacer test is displayed on the menu only if the pacer option is installed (CodeMaster XL+ only).

CALIBRATE DEFIB

Calibrates the defibrillator. The date when calibration was last performed is normally shown to the right. The date disappears if the stored value that the defibrillator test measures is lost. In either case, performing defibrillator calibration puts the test date on the menu. See "Setup/Diagnostic Menu Tests" on page 3-10 for test information.

SETUP MENU 1

SETUP MENU 2

Displays setup menu 1 or 2. The date when either menu was last displayed is normally shown to the right of SETUP MENU 1. When factory defaults are restored by the user or because configuration is lost, no date is displayed. Displaying either menu puts the date on the menu.

RESTORE FACTORY SETTINGS

Changes the configuration settings in the setup menus back to the factory default settings. Exceptions are:

- LANGUAGE on setup menu 1 (maintains selected language).
- System date on setup menu 1 (remains unchanged).
- System time on setup menu 1 (remains unchanged).
- SETUP MENU 1 date is cleared.
- Stored calibration value (maintains last value measured by Defibrillator Calibration; See "Setup/Diagnostic Menu Tests" on page 3-10 for test information.)
- Shock counter (maintains current count; see "The System Log" on page 5-4 for more information.)
- System (error) log (maintains current system log data; see "The System Log" on page 5-4 for more information.)

See Figure 2-13 and Figure 2-14 for factory default settings information.

PRINT LOG

Prints the system (error) log. See "The System Log" on page 5-4 for more information.

TEST >>>>

These menu items test defibrillator operation. See "Setup/Diagnostic Menu Tests" on page 3-10 for test information.

Displaying/Printing Configuration Settings

To display or print the configuration settings, follow the steps described in Table 2-3.

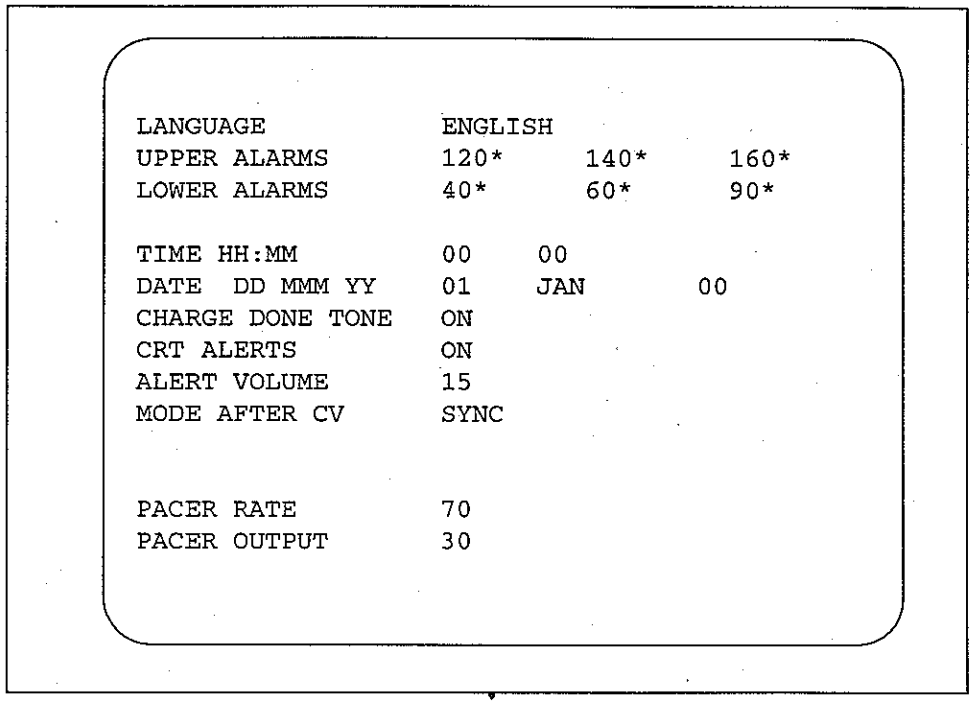
Table 2-3 Displaying/Printing a Configuration Setting

Description	Process
Display the setup/diagnostic menu	Press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from **Off (Standby)** to the **Monitor On** position.
Highlight the setup menu	Press (▼ ECG Size) or (ECG Size▲) to move the highlight over SETUP MENU 1 or SETUP MENU 2.
Display the setup menu	Press (Lead Select) to select the highlighted menu. The display changes to show the configuration settings in the setup menu you selected. The configuration settings listed in each setup menu are shown in Figure 2-13 and Figure 2-14.
Print the current configuration settings	Press (Record). The recorder prints the current settings for *both* setup menus.
Exit the setup menu	Press both arrows on the (▼ ECG Size▲) key, simultaneously, to return to the main setup/diagnostic menu.
Exit setup/diagnostic menu	Turn Energy Select to the **Off (Standby)** position to exit the setup/diagnostic menu.

NOTE

The (▼ ECG Size▲) key has both up and down arrows; pressing ▲ moves the highlight up, and pressing ▼ moves the highlight down.

Figure 2-13



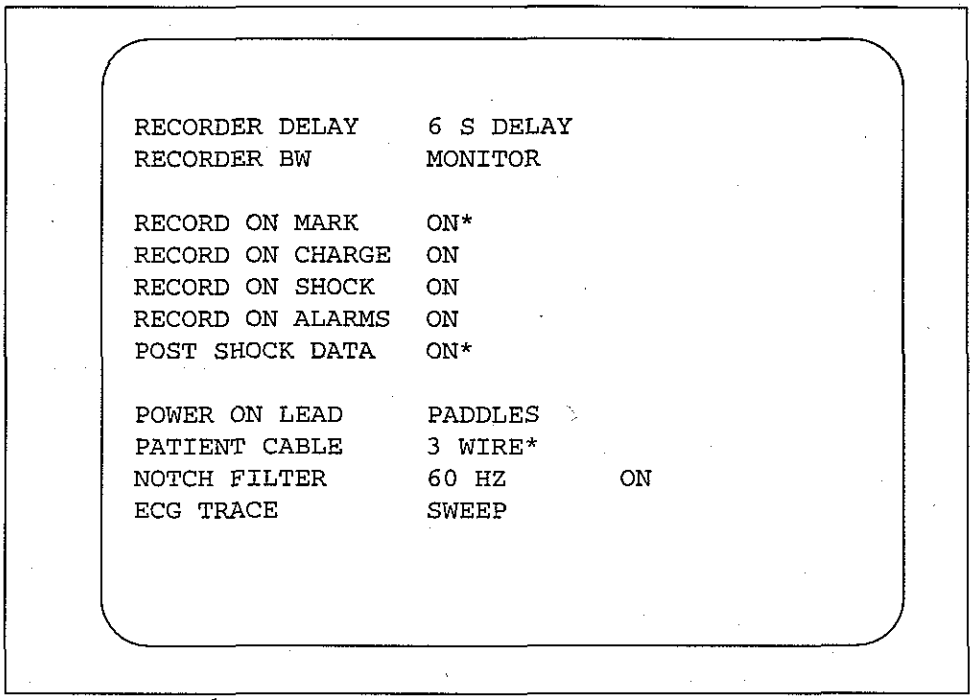
Configuration Default Settings—Setup Menu 1

*These values are fixed, not configurable, and not displayed for the CodeMaster XL.

NOTE

The pacer information is displayed only if the pacer option is installed in the instrument (CodeMaster XL+ only).

Figure 2-14


RECORDER DELAY 6 S DELAY
RECORDER BW MONITOR
RECORD ON MARK ON*
RECORD ON CHARGE ON
RECORD ON SHOCK ON
RECORD ON ALARMS ON
POST SHOCK DATA ON*
POWER ON LEAD PADDLES
PATIENT CABLE 3 WIRE*
NOTCH FILTER 60 HZ ON
ECG TRACE SWEEP

Configuration Default Settings—Setup Menu 2

*Not shown for CodeMaster XL. Note that for the Codemaster XL, RECORD ON MARK is fixed ON, POST SHOCK DATA is fixed OFF, and only the 3-wire paddle set is supported. To return to the main setup/diagnostic menu, press both arrows on the (▼ECG Size▲) key, simultaneously.

To exit the menus, turn the Energy Select control to the **Off (Standby)** position.

Changing Configuration Settings

To change a configuration setting or to change the current date, use the process described next.

WARNING

The setting values of some configuration settings can have critical impact on how your defibrillator operates. Because of this, it is recommended that the biomedical department standardize on a configuration for all defibrillators at the same facility.

If the defibrillator loses your configuration settings, it will display the message SETUP LOST on the screen and use the factory settings for all setup values. To clear the SETUP LOST message, display setup menu 1 or setup menu 2. The "Setup Lost" condition will be cleared when you view the setup menus. You do not have to change the values if you want to keep the factory settings.

Table 2-4 Changing a Configuration Setting

Description	Process
Display the setup/diagnostic menu	Press both the (Sync) and (HR Alarm) keys while turning the Energy Select control from **Off (Standby)** to the **Monitor On** position.
Highlight the setup menu	Press (▼ ECG Size) or (ECG Size▲) to move the highlight over SETUP MENU 1 or SETUP MENU 2. The configuration settings listed in each setup menu are shown in Figure 2-13 and Figure 2-14.
Display the setup menu	Press (Lead Select) to select the highlighted menu. The display changes to show the configuration settings in the setup menu you selected.
Highlight the setting you want to change	Press (▼ ECG Size) or (ECG Size▲) until the highlight appears on the setting you wish to change.
Select the highlighted setting	Press (Lead Select).
Scroll through the possible settings	Press (▼ ECG Size) or (ECG Size▲).
Select the setting	When the choice you want is displayed, press (Lead Select) to set your choice. Repeat this process to change another configuration setting, if desired.
Exit the setup menu	Press both arrows on the (▼ ECG Size▲) key, simultaneously, to return to the main setup/diagnostic menu.
Store settings and exit setup/diagnostic menu	Turn Energy Select to the **Off (Standby)** position to store your setting changes in memory and exit the menus.

Table 2-5 and Table 2-6 show the configuration items and list possible settings. You can change the settings back to the default settings by selecting

RESTORE FACTORY SETTINGS on the setup/diagnostic menu. See "Displaying/Printing Configuration Settings" on page 2-20 for information on restoring factory default settings.

Table 2-5 Configuration Settings—Setup Menu 1

Configuration Item	Setting Choices	Comments
Language	English, Spanish, Italian, German, French, Swedish, Dutch, Finnish, Danish, Norwegian, Japanese	Selects the language for printed and displayed text.
Upper Alarms[1]	From lower alarm limit to 280, in increments of 5	Sets three upper heart rate limits.
Lower Alarms[1]	From 20 to upper alarm limits, in increments of 5	Sets three lower heart rate limits. In normal operation, one set of limits is displayed and you can cycle through the three limits sets to select the set you want. The first set consists of the upper and lower limits shown on the left in setup menu 1. The second set is the middle setting for each limit. The third set consists of the settings for each limit shown on the right.
Time	hh:mm	Sets the current time.
Date	dd:mmm:yy	Sets the current date.
Charge Done Tone	On or Off	For ON, the defibrillator sounds a continuous tone while it is armed.
CRT Alerts	On or Off	For ON, the defibrillator beeps three times when any CRT Alert message is displayed. OFF turns off CRT alerts.
Alert Volume	3 to 15 (loudest)	Selects the volume of CRT Alerts and HR Alarms.
Mode after CV	Sync or Defib	Selects the defibrillator mode after cardioversion. For SYNC, the defibrillator discharges at next R-wave after the user presses both Shock buttons; for DEFIB, the defibrillator discharges only when user presses discharge buttons.
Settings for the pacer (Option—CodeMaster XL+ only): (Shown when pacer is turned on)		
Pacer Rate	40 to 180 ppm in increments of 10.	Selects the number of pacer pulses per minute (ppm).
Pacer Output	30 to 200 mA in increments of 10.	Selects the amplitude (level) of the pacer pulses, in mA.

[1]For the CodeMaster XL, the limits values cannot be changed; the factory default values listed in Figure 2-13 and Figure 2-14 are used.

Disabling the Internal Pace Pulse Detection Marker

In normal operation, the defibrillator detects internal pace pulses when monitoring with leads. Internal pace pulse detection is indicated on the screen by a negative spike relative to the ECG baseline.

NOTE Regardless of this configuration setting, the machine will continue to reject patient internal pace pulses for heart rate calculation.

To enable or disable the Pace Pulse Marker, press (Sync), (HR Alarm), and (Mark) simultaneously while in Setup Menu 1. To determine if this feature is enabled, print out the system log. See "The System Log" on page 5-4 for an explanation of the system log.

Table 2-6 Configuration Settings—Setup Menu 2

Configuration Item	Setting Choices	Comments
Recorder Delay	6 S Delay or No Delay	Recorded ECG is delayed 6 seconds after event, or starts printing immediately.
Recorder BW	Diagnostic or Monitor Diagnostic Frequency Response is only available when monitoring with leads.	Selects the bandwidth of recorder printout. For DIAGNOSTIC, frequency response is from 0.05 to 150 Hz; for MONITOR, from 0.5 to 40 Hz.
Record on Mark[1]	On or Off	For ON, the recorder prints when (Mark) is pressed.
Record on Charge	On or Off	For ON, the recorder prints when (Charge) is pressed.
Record on Shock	On or Off	For ON, the recorder prints following a discharge.
Record on Alarms	On or Off	For ON, the recorder prints when a heart rate or SpO_2 alarm violation occurs.
Post Shock Data[1]	Off or On	For ON, recorder prints the delivered (actual) energy statistics. For OFF, recorder prints the Energy Select control setting.
Power On Lead	Paddles, Lead I, II, or III	Selects the default ECG monitoring source at power-on.
Patient Cable[1]	3 Wire or 5 Wire	Sets the defibrillator to treat the input as if either a 3-wire or 5-wire patient cable is attached to the ECG Input connector.
Notch Filter	50 Hz or 60 Hz, On or Off	Selects power line filter frequency, and turns filter on or off.
ECG Trace	Sweep or Scroll	Selects the ECG trace style. SWEEP updates the displayed patient data from left to right, and then repeats the update. For SCROLL, the displayed patient data "moves" from the right to left sides of the display.

[1]On the CodeMaster XL, these menu items cannot be changed; it uses the factory default settings. See Figure 2-13 and Figure 2-14 for factory default setting information

Shock Advisory Algorithm Measurement Matrix Print (optional)

The Advisory Event Summary (AES) includes a configurable option to print the algorithm measurement matrix after each algorithm decision event. This matrix contains the measurements that the algorithm computed during the associated analysis period and on which the algorithm decision is based. This measurement can be used by a Hewlett-Packard factory service representative to understand how the algorithm decision was made.

If you have a question about the algorithm decision for a particular rhythm strip, the measurement matrix printout can be enabled and the AES reprinted with the measurement matrix information, provided the AES memory has not been erased. Save the AES printout with the measurement matrix attached at the end of the strip and contact your HP service representative.

The factory default for the measurement matrix print option is disabled. A title is printed as the top line, for example, "MEASUREMENTS 27 MAR 96 12:37:20") where the time/date is the same as the decision event time/date.

```
MEASUREMENTS   27 MAR 96   12:37:20
           D0         D1         D2         D3
M0=         x        x.x        x.x        x.x
M1=        xx       xxxx       xxxx       xxxx
M2=        xx      xx.xx      xx.xx      xx.xx
M3=       xxx     xxx.xx     xxx.xx     xxx.xx
M4=       xxx       xxxx       xxxx       xxxx
M5=      xxxx      xxxxx      xxxxx      xxxxx
M6=      xxxx      xxxxx      xxxxx      xxxxx
M7=       xxx      xx.xx      xx.xx      xx.xx
M8=       xxx     xxx.xx     xxx.xx     xxx.xx
M=9        xx      xxxxx      xxxxx      xxxxx
```

The matrix rows are for feature measurements and are labelled M0 through M9. The columns record data for internal algorithm decision points are labelled D0 through D3.

The measurement matrix printout can be enabled or disabled by entering diagnostic mode setup menu 1 and simultaneously pressing the (SYNC) and (ANALYZE) keys. This key sequence will toggle the measurement matrix print option from off to on and on to off. The status of the measurement matrix print option is recorded in the system log options area.

NOTE

Measurement Matrix can be turned ON after the unit has been powered off and then Powered on again. It will still print the Event Summary with the measurement matrix attached to each algorithm decision.

NOTE

After the unit is powered off and then on, the next ECG event, ECG alarm or Mark key pressed will erase the Event Summary. All previous information will be lost.

Performance Verification and Maintenance

Introduction

This chapter describes the performance verification and maintenance procedures recommended for the CodeMaster XL+ and XL Defibrillator/Monitor. The information is divided into these sections:

Performance Verification	How to verify the defibrillator's performance
Setup/Diagnostic Menu Tests	How to use the defibrillator's built-in menu tests to calibrate the defibrillator, check battery capacity, and do quick operational checks
Preventive Maintenance	Explains preventive maintenance procedures
Safety Tests	Presents safety testing information
Performance Verification Checklist	Provides a performance verification checklist

For simple checking without using external equipment, you can use the menu-driven tests built into the defibrillator. However, these tests are not as thorough as the tests listed for performance verification. The exception is the battery capacity test, which is a built-in menu-driven test that discharges and monitors the battery voltage. This test is included in performance verification for checking battery capacity.

Test Intervals

Performance Verification Tests

The performance verification tests should be performed every six months, and after servicing. See "Performance Verification" on page 3-4 for detailed test information.

Defibrillator Calibration

The defibrillator should be recalibrated after any of the following events:

- The user suspects that the defibrillator is delivering an energy level lower than the level selected via the Energy Select control.
- The CALIBRATE DEFIB date on the main setup/diagnostic menu is no longer displayed. See "Displaying/Printing Configuration Settings" on page 2-20 for information about the menu. (Note that the defibrillator is shipped with no date displayed).
- The SETUP LOST message is displayed on the screen. See "Configuration" on page 2-17 for information about the message.
- After servicing which requires replacement of the HV capacitor or the Control board.

See "Defibrillator Calibration" on page 3-13 for detailed information on defibrillator calibration.

Battery Capacity Test

The battery capacity test should be performed after any of the following events:

- After installing a new battery.
- After six months of service (more often if defibrillator use frequently depletes the battery without allowing time for full charge cycles).
- After the defibrillator has been stored for an extended period.

See "Battery Capacity Test" on page 3-28 for detailed information on performing this test.

Sync Cardioversion Test with External Monitor

The sync cardioversion test should be performed only if the defibrillator will be used with an external monitor as the synchronizing source. The test verifies that the delay introduced by the external monitor is within acceptable limits.

See "Sync Cardioversion Test with External Monitor" on page 3-7 for detailed information on performing this test.

Equipment List

Table 3-1 lists specifications that must be met by the equipment used to verify performance of the defibrillator. This equipment is commercially available.

Table 3-1 **Equipment List**

Equipment/Test	Specifications
Calibrated Leads ECG simulator (ECG simulation test)	±2% accuracy
Calibrated Paddles ECG simulator (ECG simulation test)	±2% accuracy
AAMI patient termination (ECG simulation test)	47 nF in parallel with 51 K ohms together in series with each lead wire.
Defibrillator test box	
(Delivered energy level test)	
Load resistance:	50 Ω ±1% (non-inductive)
Measurement range	
Maximum energy:	≥450 joules
Maximum voltage:	≥6000 V
Maximum current:	≥120 A
Measurement accuracy	
≥20 joules:	≤±2% of reading (damped sinusoidal waveform)
<20 joules:	≤±0.4 joules (damped sinusoidal waveform)
Cardioversion measurement range:	−150 to +150 ms
Pacer tester	
Load impedance:	≤400Ω
Current measurement accuracy	
30 mA–50 mA:	< ±2 mA
50 mA–200 mA:	< ±4%
Rate measurement accuracy	
40–180 ppm:	< ±0.5%
Waveform duration accuracy:	±1ms

In addition, a test load is available for testing the external pads adapter (HP M1781A).

Performance Verification

Verify the performance of the defibrillator every six months. The procedures listed below make up performance verification. For daily check of the defibrillator, see "Operational Checks" in the *CodeMaster XL+/XL Defibrillator/Monitor User's Guide*"

- Visual inspection of the defibrillator exterior
- Delivered energy level test*
- Pacer test (Option—CodeMaster XL+ only)*
- SpO_2 test (Option)
- HR Alarm test
- Visual examination of an ECG recorded from an ECG patient simulator*
- Battery capacity test. See"Battery Capacity Test" on page 3-28 for detailed information on performing this test.

The performance verification checklist at the end of this chapter summarizes the tests you should perform to verify the defibrillator's performance. These are some suggested uses for this checklist:

- Make copies of the blank checklist; then, fill out a copy each time the defibrillator is tested.
- Attach the recorder test output, simulator ECG trace, and error log printout to the completed checklist and file with the defibrillator's permanent maintenance record.

Visual Inspection

Before beginning the inspection, turn the Energy Select control to **Off (Standby)**, and unplug the power cord from the wall outlet. Then inspect the defibrillator for the following:

- Worn or damaged power cord
- Loose or missing hardware
- Mechanical damage

---

* Requires special calibrated test equipment. See "Equipment List" on page 3-3 for more information on equipment and sources.

- Evidence of liquid spill
- Worn recorder drive gear
- Worn recorder roller
- Corroded or damaged electrodes
- Worn or damaged cables or connectors
- Foreign material on the thermal printhead or paper sensor

Replace any damaged or missing items, and clean the printhead, paper sensor, and patient electrodes as necessary. leaning instructions are listed under "Preventive Maintenance" on page 3-32.

Connect the defibrillator to AC power; observe that the (AC POWER) and (BATT CHRG) indicators come on. Turn the Energy Select control to **Monitor On**, and observe that the (Charge) and (Sync) indicators light momentarily, and that the monitor screen displays a trace and other information. Also, the (Pacer On) indicator should light momentarily (if pacer is installed).

Delivered Energy Level Test

To perform the delivered energy level test, you need a test box. See Table 3-1 for equipment specifications. The test checks that the delivered discharge energy measured by the test box is equivalent to the charge level displayed on the defibrillator.

To verify the delivered energy level, follow the instructions provided with the test box.

WARNING

Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltage exists on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.

Pacer Test

Testing the pacer does not check the energy level that pacing delivers; testing verifies that the current delivered is equivalent to the levels indicated on the defibrillator screen.

To verify pacer operation, use a commercially available pacer tester. See Table 3-1 for equipment information. Follow the instructions provided with the pacer tester to perform the test.

SpO_2 Test

Testing of the SpO_2 option includes an internal self-test and a functional test.

SpO_2 Internal Self-Test

Every time the SpO_2 monitoring is turned on, the instrument runs a self-test on the SpO_2 PCA.

1 Turn the defibrillator on by turning the Energy Select switch to Monitor On.

2 Press the SpO_2 On/Off button to turn SpO_2 monitoring on.

3 Verify that no error messages appear on the display.

4 Press the SpO_2 On/Off button to turn SpO_2 monitoring off.

SpO_2 Functional Test

1 Attach an SpO_2 sensor to a normal, healthy person. Refer to the sensor packaging for directions on how to attach the sensor.

2 Plug the sensor into the defibrillator. If you are not using a Hewlett-Packard sensor, you must use the M1900B adaptor cable.

3 Turn the Energy Select switch to Monitor On.

4 Press the SpO_2 On/Off button.

5 After 15 seconds, verify that the display shows an SpO_2 reading and a pulse rate.

6 Verify that the Pulse Amplitude Indicator moves up and down.

7 Verify that the SpO_2 reading is between 95% and 100%. If the SpO_2 reading is much below 95% and the person is healthy, the reading indicates a monitor or sensor error.

8 Press the SpO_2 On/Off button to turn SpO_2 monitoring off.

HR Alarm Test

To test the HR Alarm an ECG simulator is needed.

1 Run a normal ECG at 60 Hz

2 Press (HR Alarm), verify alarm setting in upper right corner of the display

3 Change the ECG simulator to get beyond both the upper and lower HR Alarm limits.

4 After a few seconds (approximately six seconds) the recorder will print a report and the alarm will sound.

ECG Simulation

Taking an ECG using a 12-lead ECG simulator lets you verify areas of operation that the setup/diagnostic menu tests cannot test:

- the integrity of the leadwires
- the accuracy of the gain settings

To simulate an ECG, use a commercially available ECG simulator. Follow the testing instructions provided with the simulator.

Sync Cardioversion Test with External Monitor

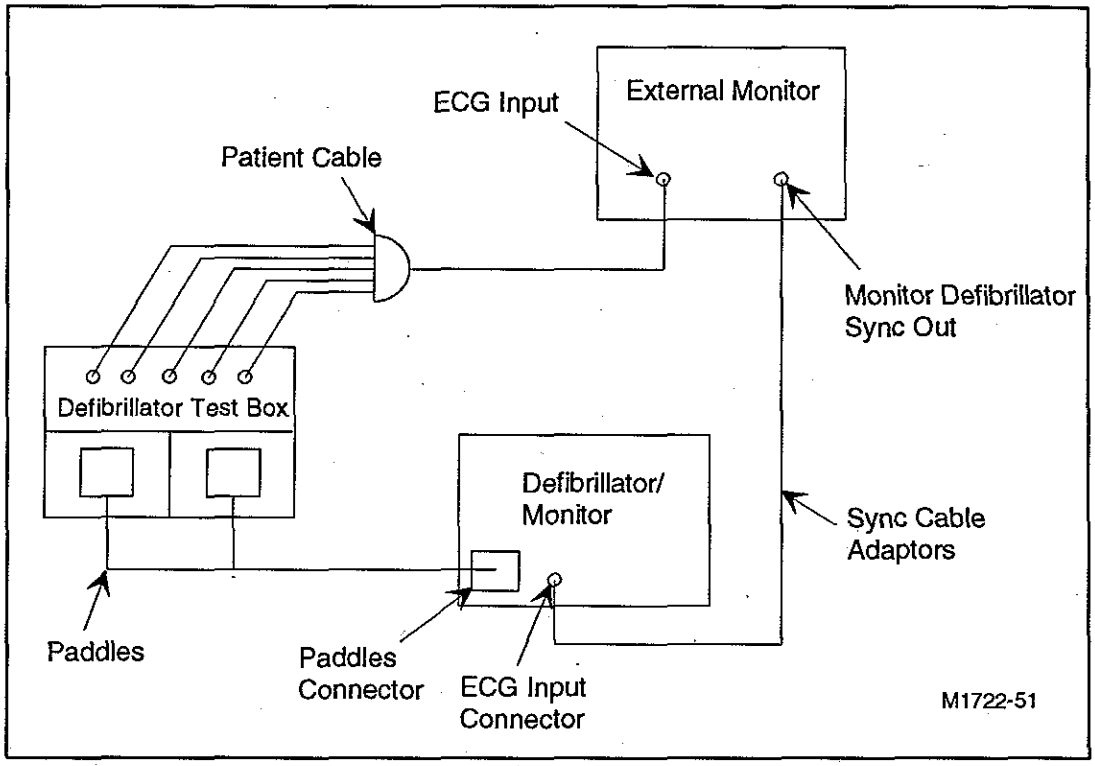
Using an external monitor as the synchronizing source adds some amount of delay between the patient R-wave and defibrillator discharge. This test verifies that the total delay is within acceptable limits.

To test sync cardioversion with an external monitor, follow this procedure:

1 Use a defibrillator test box capable of measuring synchronized cardioversion delay time.

2 Connect a patient cable between the defibrillator test box and the external monitor. See Figure 3-1.

Figure 3-1



Sync Cardioversion Test Setup

3 Connect the sync interface cable between the external monitor's DEFIB/SYNC output and the defibrillator ECG In connector.

4 Set up the external monitor to monitor LEAD II.

5 On the defibrillator, select LEAD II as the ECG source.

6 Put the defibrillator test box into cardioversion test mode.

7 Press (Sync) on the defibrillator to put the instrument in sync mode. The ECG signal should have synchronization markers highlighting the ECG trace. Adjust ECG SIZE, if necessary.

8 Turn the Energy Select control on the defibrillator to 50 joules.

9 Place the paddles on the defibrillator test box paddle pads; press the charge button on the apex paddle. Wait for the Charge Done indicators on the defibrillator.

10 Press and hold both shock buttons on the paddles until the defibrillator discharges.

11 Verify that the measured cardioversion delay time is less than 60 ms.

Setup/Diagnostic Menu Tests

The setup/diagnostic menu tests provide an easy method to check most areas of defibrillator operation and the battery capacity. These tests are available in the setup/diagnostic menu:

- Defibrillator test
- ECG test
- CRT test
- Recorder test
- Controls test
- Indicators test
- Battery capacity test
- Pacer test (Option—CodeMaster XL+ only)

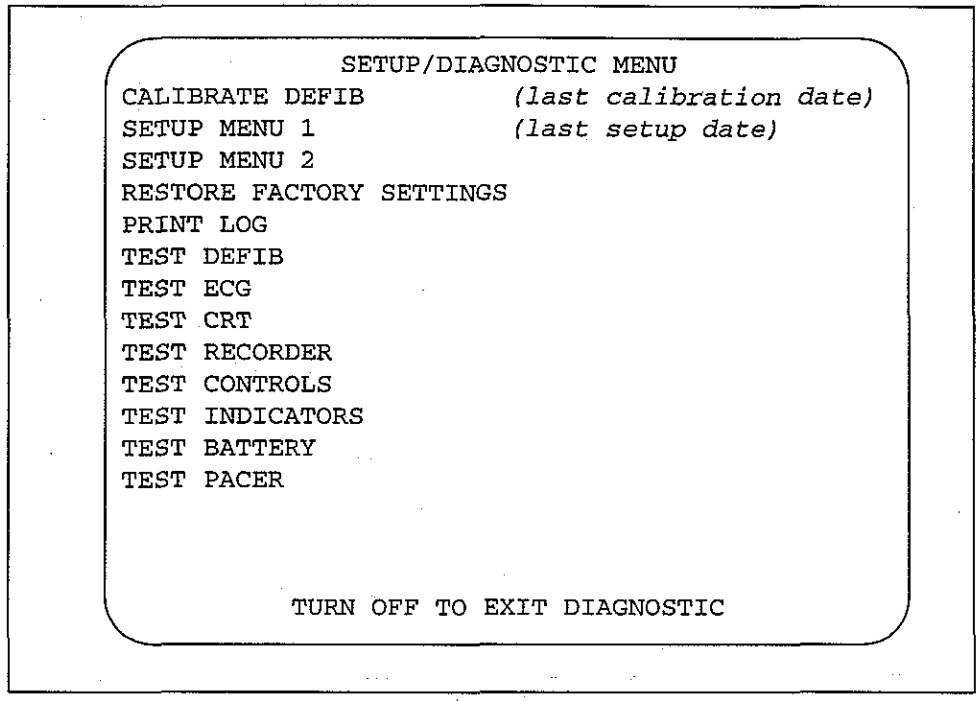
The CRT test, recorder test, controls test, and indicators test require visual verification of displayed or printed output. For these tests, visible failure symptoms appear in the displayed or printed test information, or are shown by indicator operation. For other tests, you determine whether a test has failed by examining test-results data shown on the display.

NOTE

The setup/diagnostic tests do not test the patient electrodes or the 3- or 5-wire patient cables. You can test the patient electrodes and cables by recording an ECG from a patient or ECG simulator as described in "ECG Simulation" on page 3-7.

To access the setup/diagnostic menu tests, turn the Energy Select control to **Monitor On**, while pressing the (Sync) and (HR Alarm) keys. The following display appears:

Figure 3-2



Setup/Diagnostic Menu

NOTE

The pacer test is listed only if the pacer option is installed (CodeMaster XL+ only).

The dates appear only if the unit has already been calibrated and the configuration has been set up. See "Configuration" on page 2-17 for detailed information.

The setup/diagnostic menu lists the built-in tests and other items. With the panel keys, you step through the menu items and select tests. When you select a test, the display changes to show test information. Using the panel keys to select and start a test is described in Table 3-2. These two keys select and initiate a test:

▼ ECG Size ▲	Moves the highlight bar down or up, depending on whether you press the left or right side of the key.
Lead Select	Selects the menu item that is highlighted.

Table 3-2 **Performing a Setup/Diagnostic Test**

Description	Process
Highlight the setup/diagnostic menu test	Press (▼ ECG Size) to highlight the test name in the menu.
Select the test	Press (Lead Select) . For some tests, the test that you selected then starts running, and repeats until you stop it. For other tests, the display changes to show test patterns or other test information.
Perform the test	Follow the instructions in this chapter for the test you selected.
To stop a test or return to the setup/diagnostic menu	Press both arrows on the (▼ ECG Size ▲) key simultaneously.
To exit the setup/diagnostic menu or exit a test	Turn the Energy Select control to **Off (Standby)**.

Defibrillator Calibration

When the defibrillator charges, it uses a measured value for the capacitance of the charge capacitor to determine the energy required to reach the selected charge level. The CALIBRATE DEFIB choice on the menu guides the user through a routine that measures the capacitance of the HV capacitor, and adjusts the capacitance value based on the routine's results. The capacitance value is stored in battery-maintained memory and used each time the defibrillator is charged. On the TEST DEFIB screen, the stored capacitance value is displayed after CAPACITANCE.

WARNING

Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltage exists on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.

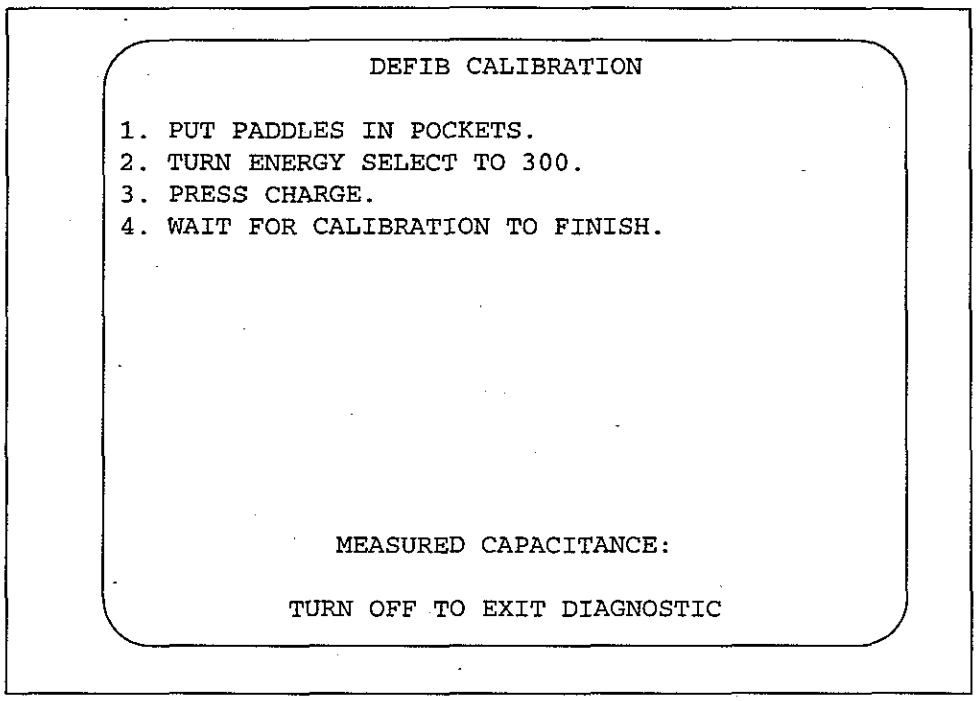
Test Prerequisites

Connect the external paddles and place them firmly in their holders in the defibrillator.

Calibrating the Defibrillator

To start the defibrillator calibration routine, select CALIBRATE DEFIB on the setup/diagnostic menu; the screen displays the information shown in Figure 3-3.

Figure 3-3


DEFIB CALIBRATION
1. PUT PADDLES IN POCKETS.
2. TURN ENERGY SELECT TO 300.
3. PRESS CHARGE.
4. WAIT FOR CALIBRATION TO FINISH.
MEASURED CAPACITANCE:
TURN OFF TO EXIT DIAGNOSTIC

Calibrate Defibrillator Screen

Follow the instructions displayed on the screen. (If you set the Energy Select control to a level below 300 joules, the message, `BAD USAGE: SEE MANUAL` is displayed.)

If the test completes successfully, `CALIBRATION PASSED` is displayed at the bottom of the screen. If the test fails, `CALIBRATION FAILED` is displayed and the nominal capacitance value is used; see Chapter 5, **Troubleshooting**, for detailed troubleshooting information.

Defibrillator Test

This test verifies defibrillator performance to specifications. You should run the Defibrillator Calibration routine before performing the Defibrillator Test. You can perform the defibrillator test using either external paddles or pads.

WARNING

If using pads adapter M1750A/B, connect an M1781A test load when performing the defibrillator test.

Test Prerequisites

Connect the external paddles and place them firmly in their holders in the defibrillator, or attach the M1781A test load if you are using pads. The battery must be fully charged.

Testing the Defibrillator

It is recommended that you test the defibrillator in the power configuration in which it is normally used: battery only, or AC power. You should also test the disarm function as described at the end of the defibrillator test.

The test is designed to check the defibrillator in these power configurations:

- With fully-charged battery installed; no AC power.
- With the defibrillator plugged into AC power; battery is removed.

With the defibrillator powered by battery only, you run the test at 100 and at 360 joules. The values of some test results vary depending on the power configuration being used. Table 3-3 lists acceptable test result values for each power configuration.

To run the Defibrillator Test, follow these steps:

1 **For battery only testing:**

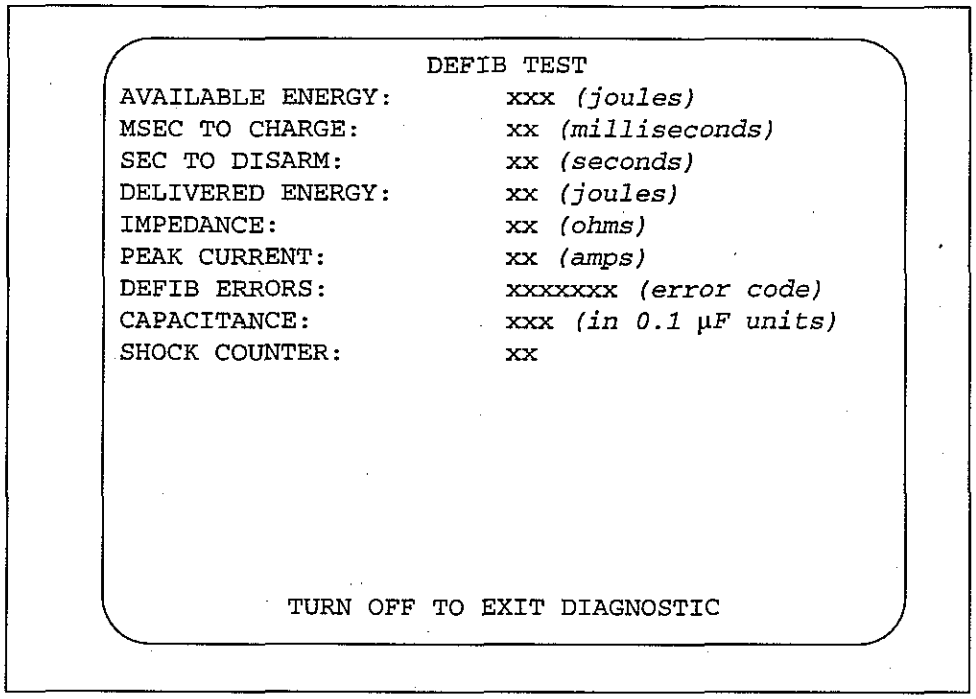
   a. Make sure that the battery is installed and is fully charged.
   b. Disconnect the defibrillator from AC power.

   For AC power only testing:

   a. Disconnect the battery.
   b. Plug the defibrillator into AC power.

2 Select TEST DEFIB in the setup/diagnostic menu; the screen displays the information shown in Figure 3-4. This table shows defibrillator performance parameters. Some of these parameters are not available until after the defibrillator is discharged.

Figure 3-4


DEFIB TEST
AVAILABLE ENERGY: xxx (joules)
MSEC TO CHARGE: xx (milliseconds)
SEC TO DISARM: xx (seconds)
DELIVERED ENERGY: xx (joules)
IMPEDANCE: xx (ohms)
PEAK CURRENT: xx (amps)
DEFIB ERRORS: xxxxxxx (error code)
CAPACITANCE: xxx (in 0.1 µF units)
SHOCK COUNTER: xx
TURN OFF TO EXIT DIAGNOSTIC

Defibrillator Test Screen

AVAILABLE ENERGY:	Current charge in joules; 0 when the defibrillator is not armed.
MSEC TO CHARGE:	After the defibrillator charges to the energy level selected, the entry shows how many milliseconds the charge required.
SEC TO DISARM:	After the defibrillator signals Charge Done, it holds the charge for 60 seconds, and then starts disarming the charge through an internal safety relay. The entry shows the time required to disarm the defibrillator to the "safe" state.
DELIVERED ENERGY:	The calculated delivered energy (in joules) based on the internal peak current measurement.
IMPEDANCE:	The calculated load impedance based on available energy and the internal peak current measurement (in Amps).
PEAK CURRENT:	The peak current measured during defibrillator discharge.
DEFIB ERRORS:	Defibrillator errors that have occurred while in diagnostic test mode.
CAPACITANCE:	The capacitance used when charging the defibrillator. The capacitance value is established during Defibrillator Calibration (See "Defibrillator Calibration" on page 3-13 for information).

SHOCK COUNTER: The number shown is the number of shocks since the shock counter was reset. You can clear the shock counter by pressing the (Sync) and (HR Alarm) keys simultaneously, while displaying this screen. Only clear the shock counter after replacing a patient circuit component, such as the high voltage (HV) capacitor, HV inductor, patient relay, or HV charger board. Record the value of the shock counter prior to clearing it.

3 Turn the Energy Select control to the energy level for the power configuration you selected.

4 Press (Charge). The value for AVAILABLE ENERGY increments.

5 Check that it reaches the energy level you selected, when the Charge Done LED is lit on the front panel or the apex paddle.

6 Check that the entry for MSEC TO CHARGE is within the limits listed in Table 3-3 for the power configuration you selected.

WARNING

Avoid touching any metal surfaces on the defibrillator and do not touch equipment connected to the defibrillator during shock. Dangerous high voltages exist on the paddles when the defibrillator is discharged. Contact with this high voltage could cause death or serious injury.

7 Discharge the defibrillator by pressing the two shock buttons.

8 Check that the values for DELIVERED ENERGY, IMPEDANCE, and PEAK CURRENT are within the limits listed in Table 3-3.

NOTE

If the displayed Impedance is outside these limits, see "Adjusting the Internal Delivered Energy Calibration" on page 6-33.

To test the automatic disarm function:

9 Press (Charge) again.

10 Wait until an alternating tone sounds, and then the AVAILABLE ENERGY value decrements to 0.

11 Repeat the test for the other power configuration if you are doing the battery only test; or for the other energy level, if desired.

Table 3-3 Defibrillator Test Limits

Defibrillator Configuration	Available Energy	MSec to Charge	Sec to Disarm	Delivered Energy	Impedance	Peak Current
Battery Only	100 j	<2000	–	85–115 j	45–55Ω	26–33 A
	360 j	<5000	–	306–414 j	45–55Ω	50–60 A
AC Only (Battery removed)	360 j	<15000	–	306–414 j	45–55Ω	50–60 A
Disarm Test	360 j	–	<7 sec			

To test the manual disarm function:

12 Turn the Energy Select control to 360 joules.

13 Press (Charge).

14 When the charge reaches 360 joules, turn the Energy Select control directly to **Monitor On**. Turn the control quickly and do not stop at any level selection between 360 joules and the **Monitor On** position. This step disarms the defibrillator.

15 Check that the SEC TO DISARM value displayed on the screen is within the limits listed in Table 3-3.

16 Press both sides of (▼ECG Size▲) at once, to exit the test menu.

ECG Monitor Test

This test verifies the operation of the leads and paddles ECG front end amplifiers, and checks digital signal processor filtering. The test also verifies communication between the front end board and the control board.

Test Prerequisites

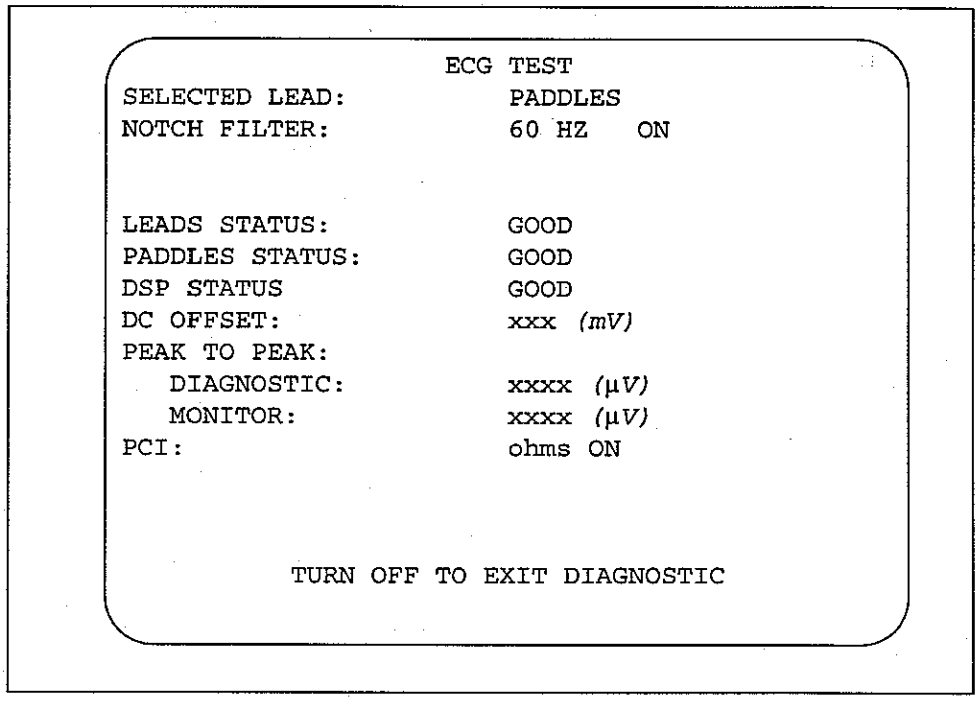
Requires a calibrated ECG simulator for use with pads and leads. Also requires an AAMI simulated patient load. See "Equipment List" on page 3-3 for equipment information.

Testing the ECG

Monitor To run the ECG test, follow these steps:

1 Select TEST ECG in the setup/diagnostic menu; the display shows the information shown in Figure 3-5.

Figure 3-5



ECG (Monitor) Test

SELECTED LEAD:	Lets you select the ECG source.
NOTCH FILTER:	Current power line filtering frequency: 50 or 60 Hz; you can change the filtering and turn the filter off and on.
LEADS STATUS:	GOOD indicates that communication between the Leads Front End and DSP is acceptable.
PADDLES STATUS:	GOOD indicates that communication between the paddles/ Front End and DSP is acceptable.
DSP STATUS:	GOOD indicates that the DSP is communicating properly with the monitor.
DC OFFSET:	An offset value used when measuring Leads Off. Largest absolute value offset of any wire used in lead combination according to the lead selected (mV).
PEAK TO PEAK DIAGNOSTIC: MONITOR:	Peak-to-peak signal of the SELECTED LEAD measured over a one-second interval. Results are given for both MONITOR (0.5Hz to 40 Hz) and DIAGNOSTIC (0.05Hz to 150 Hz) bandwidth.

PCI: Paddles impedance measured in ohms. Used to determine PADDLES OFF, and for PCI (paddles contact indicator) bar graph on sternum paddle. Patient impedance can be calibrated. See "PCI Calibration" on page 3-21 for instructions. PCI ON indicates that displayed data is calibrated. PCI OFF indicates that displayed data is not calibrated.

2 Check that LEADS STATUS is GOOD.

3 Check that PADDLES STATUS is GOOD.

4 Check that DSP STATUS is GOOD.

5 This step checks ECG leads gain.

a. Connect the leads front end cable to the patient simulator.
b. Apply a 1 mV sine wave at 1–10 Hz to the ECG Input connector.
c. Select the appropriate leads. Most simulators have a 1mV output. However, not all leads on the simulator output 1mV. Check the simulator user's manual to determine which lead provides a 1mV output, then select the correct lead on the test screen for making measurements.
d. The screen continually updates test values shown for PEAK TO PEAK. Check that these displayed values, both MONITOR and DIAGNOSTIC, are 1000 ±10%.

6 This step checks ECG paddles gain:

a. Connect the paddles cable to the patient simulator.
b. Apply a 1 mV sine wave at 1–10 Hz to the ECG Input connector.
c. Select PADDLES at the defibrillator.
d. The screen continually updates test values shown for PEAK TO PEAK. Check that these displayed values, MONITOR is 1000 ±10%. Diagnostic bandwidth is not used for paddles ECG.

7 This step checks ECG noise with a paddles front end.

a. Choose PADDLES as SELECTED LEAD.
b. Short the ECG paddles together and read PEAK TO PEAK value, MONITOR bandwidth. Noise should be ≤30μV.

8 This step checks ECG noise with a leads front end.

a. Connect the leads cable to an AAMI patient termination.
b. Choose LEAD 1 as the SELECTED LEAD.
c. Read PEAK TO PEAK values for DIAGNOSTIC and MONITOR bandwidth. The noise value for monitor bandwidth should be ≤30μV. The noise value for diagnostic bandwidth should be ≤40μV.
d. Repeat steps a, b, and c to measure the noise level for lead.

NOTE

Noise is specified in this manual using an AAMI patient termination. If an AAMI patient termination is not available, noise can generally be measured using the ECG simulator, with simulator power turned off. However, some simulators have an output impedance which can cause erroneous results when measuring ECG noise.

PCI Calibration

PCI calibration should be performed whenever setup is lost or whenever the user suspects that PCI indication is wrong. Perform the following steps to calibrate PCI.

1 Attach the paddle set to the defibrillator.

2 Access the setup/diagnostic menu.

3 Select TEST ECG in the setup/diagnostic menu.

4 Press (Sync) and (HR Alarm) simultaneously, so that OFF appears to the right of the PCI value.

5 While shorting the paddles together, press (Sync) and (HR Alarm) simultaneously. The PCI value should now indicate 0±2 ohms and ON should now appear next to the PCI value.

NOTE

Turning the PCI indicator off, then on again calibrates it to 0 ohms. If you do not short the paddles together, you will miscalibrate the PCI indicator.

6 Replace paddles in pockets. The PCI value with the paddles in the pockets should be between 20 and 100 ohms (the PCI value varies because of inductance in the circuit).

CRT Test

This test lets you check the operation and alignment of the CRT.

Test Prerequisites

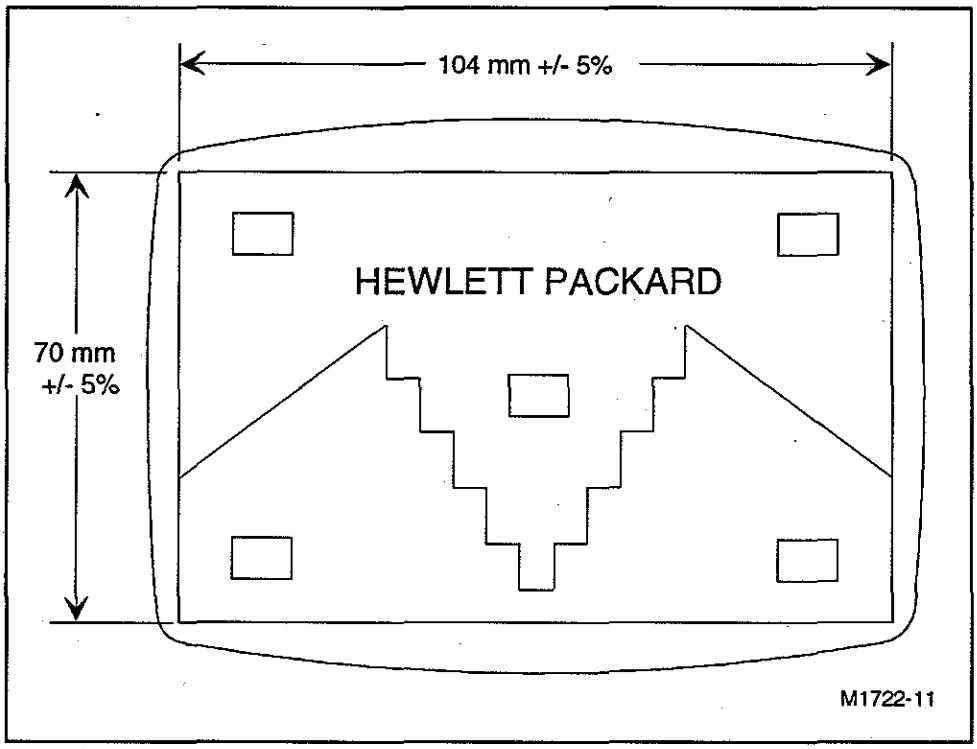
A ruler that measures in millimeters is required to measure the display size.

Testing the CRT

To perform the CRT test, follow these steps:

1 Select TEST CRT in the setup/diagnostic menu; the display shows the information shown in Figure 3-6.

Figure 3-6



CRT Test: Test Pattern

2 To determine whether the defibrillator CRT meets specifications, observe the test pattern to ensure:

- accurate rendition of all lines
- no random lines or dots in the display

NOTE

If any of the following steps require adjustment, see "Adjusting the CRT" on page 6-30 for adjustment information.

3 Check that the height and width of the display is within the limits shown in Figure 3-6.

4 Check that all lines and characters are in focus.

5 Check that the display is centered on the CRT face, vertically and horizontally.

6 Check that the display is aligned horizontally and vertically.

7 Check that the intensity of the displayed image is acceptable.

Recorder Test

The recorder test checks recorder parameters, and prints a test pattern to check the printhead and paper drive mechanism.

Test Prerequisites

Recorder paper, and a ruler that measures in millimeters.

Testing the Recorder

To run the recorder test, follow these steps:

1 Check that the recorder contains paper.

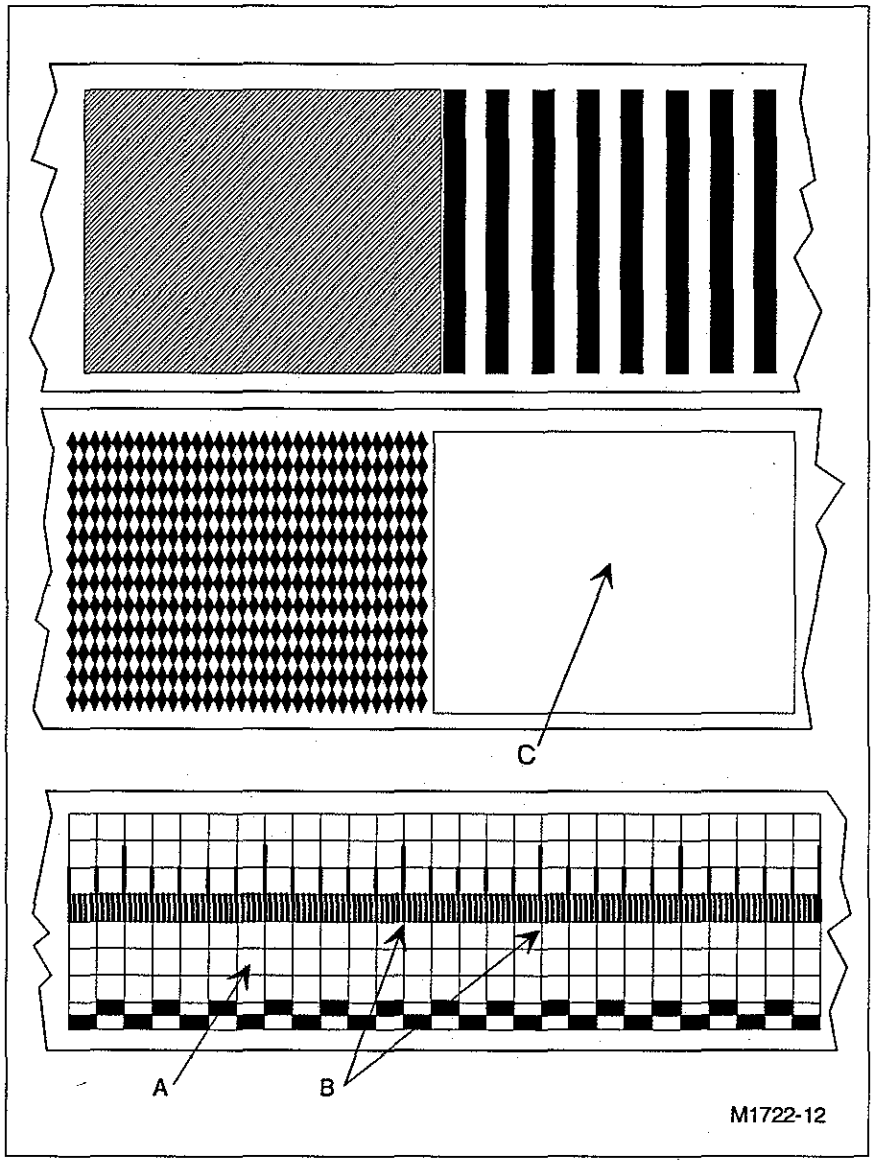
2 Highlight TEST RECORDER on the main setup/diagnostic menu.

3 Press (Record) or (Lead Select) . The recorder starts printing a series of test patterns.

4 When the printed strip is about 3 feet long, press (Record) or (▼ECG Size▲) to stop the printing and return to the setup/diagnostic menu. Figure 3-7 shows the areas of the test pattern.

- Inspect the recorder strip for: Consistent print quality for all pattern areas
- Constant width for all pattern areas
- Straight diagonal lines
- Visible separation between the close parallel lines
- Clean black bars with no dropout in black areas
- Accurate rendition of all characters
- A distance of 25 mm ±2 mm between the longest tick marks (5 mm between the intermediate tick marks)

Figure 3-7



Recorder Test: Test Pattern

A. Test pattern for checking print speed

B. Major tick marks

C. Test pattern printout of all characters and symbols.

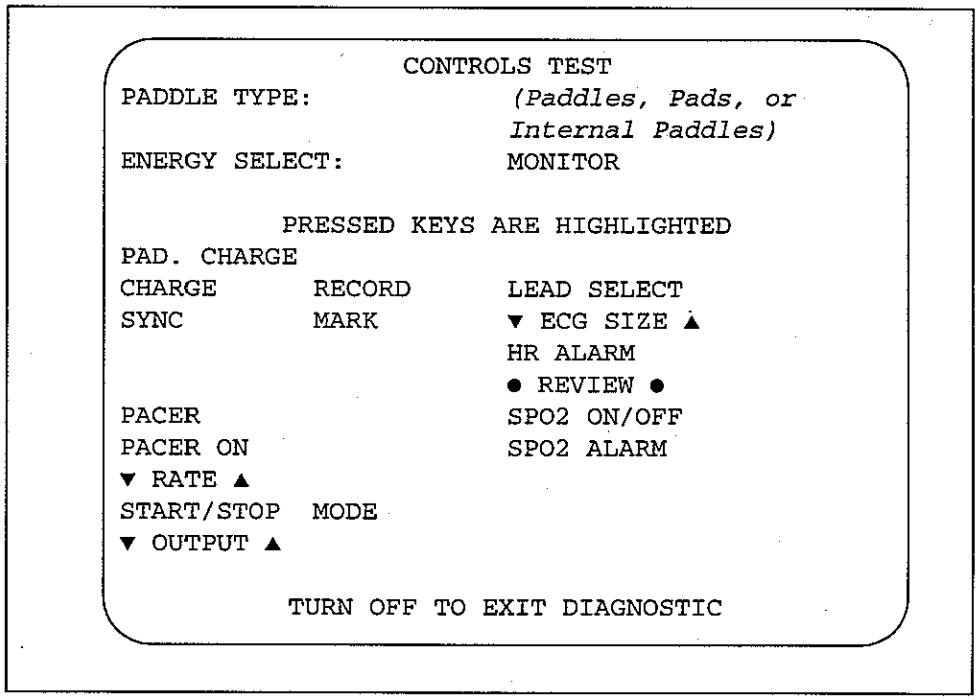
Controls Test

This test checks the operation of the panel keys.

To test the panel key operation, follow these steps:

1 Select TEST CONTROLS in the setup/diagnostic menu. The information shown in Figure 3-8 is displayed.

Figure 3-8



Controls Test

NOTE

The pacer information is displayed only if the pacer option is installed (CodeMaster XL+ only).

2 Check that the entry for PADDLE TYPE matches the type that is attached (paddles, pads, or internal paddles).

If you disconnect the paddles cable, the entry changes to NONE.

3 Turn the Energy Select control to each energy level position, checking that the entry for Energy Select on the display matches the current control position.

4 Under PRESSED KEYS ARE HIGHLIGHTED, press each key listed. Simultaneously, check that the key name in the display is highlighted while the key is

depressed. Highlighting indicates that the defibrillator has detected the key press. See Table 3-4 for a list of keys and the response you should see on the monitor display.

Table 3-4 **Controls Test Steps**

Key	Key Press	Response on Display
Paddles Charge	Press the Charge button on the side of the right external paddle.	PADDLES,PADS, or INTERNAL PADDLES is highlighted.
(Charge)	Press the panel (Charge) key.	CHARGE is highlighted.
(Sync)	Press the panel (Sync) key.	SYNC is highlighted.
(Record)	Press the panel (Record) key.	RECORD is highlighted.
(Mark)	Press the panel (Mark) key.	MARK is highlighted.
(Lead Select)	Press the panel (Lead Select) key.	LEAD SELECT is highlighted.
(▼ ECG Size ▲)	Press the panel (▼ ECG Size) key.	The ▼ arrow is highlighted.
	Press the panel (ECG Size ▲) key.	The ▲ arrow is highlighted.
(HR Alarm)	Press the panel (HR Alarm) key.	HR ALARM is highlighted.
(● Review ●)	Press the (● Review) key.	The left ● is highlighted.
	Press the panel (Review ●) key.	The right ● is highlighted.
XL+ only, with pacer option installed:		
(Pacer On)	Press the (Pacer On) key.	PACER ON is highlighted.
(▼ Rate ▲)	Press the panel (▼ Rate) key.	The ▼ arrow is highlighted.
	Press the panel (Rate ▲) key.	The ▲ is highlighted.
(Start/Stop)	Press the panel (Start/Stop) key.	START/STOP is highlighted.
(▼ Output ▲)	Press the panel (▼ Output) key.	The ▼ arrow is highlighted.
	Press the panel (Output ▲) key.	The ▲ arrow is highlighted.
(Mode)	Press the panel (Mode) key.	MODE is highlighted.
With SpO_2 option installed:		
(SpO_2 On/Off)	Press the panel (SpO_2 On/Off) key	SPO2 ON/OFF is highlighted.
(SpO_2 Alarm)	Press the panel (SpO_2 Alarm) key	SPO2 ALARM is highlighted.

Indicator Test

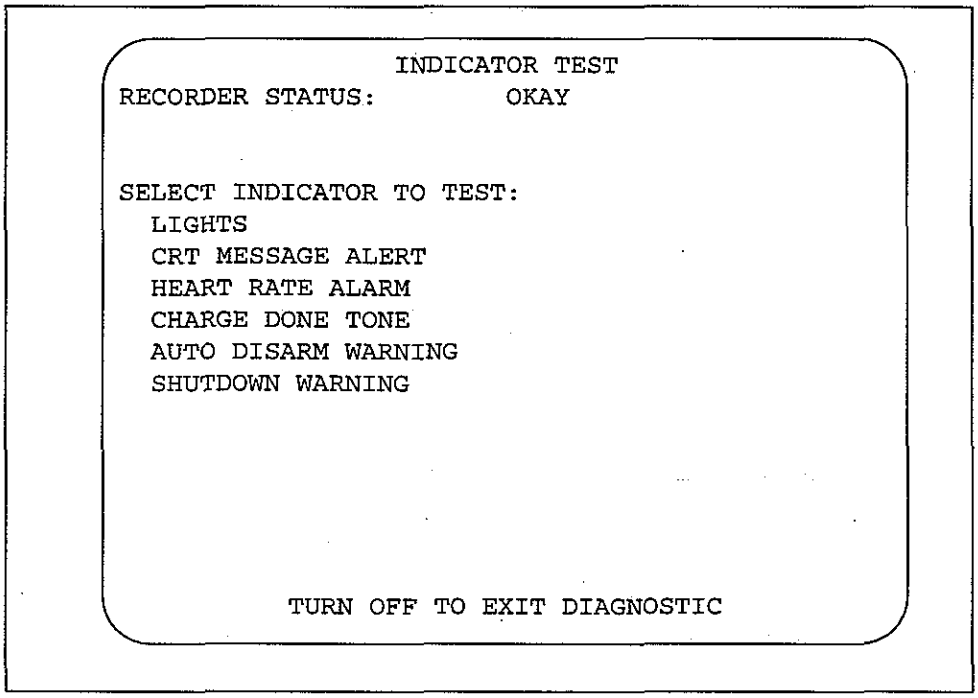
The indicator test exercises each LED and audio tone controlled by the defibrillator.

Testing the Indicators

To test the defibrillator indicators, follow these steps:

1 Select TEST INDICATORS on the setup/diagnostic menu; the defibrillator displays the information in Figure 3-9.

Figure 3-9



Indicators Test

2 Check that the entry for RECORDER STATUS is OKAY. (If the recorder is out of paper, the entry is CHECK.)

3 The items under SELECT INDICATOR TO TEST are tests for the lights and audible tones. Use the (▼ECG Size▲) and (Lead Select) keys to select and start a test. To stop one of these tests, press (Lead Select) again. Each test is described, next.

LIGHTS	Sequentially lights the (Sync), the key panel (CHARGE DONE), the pacer (Pacer On), and the paddle (CHARGE DONE) indicators for about one second, each. If the unit has PCI indicators, they are lit while the LIGHTS test is running.
CRT MESSAGE ALERT	Generates the CRT Alert tone: three short tones; after a pause, the tones repeat.

HEART RATE ALARM	Generates a continuous tone.
CHARGE DONE TONE	Generates a continuous tone; this tone is lower in frequency than the Heart Rate Alarm tone.
AUTO DISARM WARNING	Generates an intermittent tone that is the same frequency as the Charge Done tone.
SHUTDOWN WARNING	Outputs a tone that alternates continuously between the Charge Done tone and the HR Alarm tone frequencies.

Battery Capacity Test

The battery capacity test measures the current battery capacity. The battery capacity test should be performed after any of the following:

- After installing a new battery.
- After six months of service (more often if defibrillator use frequently depletes the battery without allowing time for full charge cycles).
- After the defibrillator has been stored for an extended period.

The total time required to perform the battery capacity test is about 30 hours. The first part of the battery capacity test involves charging the battery for eight hours to ensure sufficient charge. Once started, the battery capacity test runs for about 3.5 hours. Because the battery capacity test discharges the battery, allow an additional 18 hours after the test to re-charge the battery to full capacity.

Testing the Battery Capacity

Follow these steps to perform the battery capacity test:

1 Charge the battery by plugging the instrument into AC power for eight hours. When you start charging the battery, verify that the (AC POWER) and (BATT CHRG) lights are on.

2 Verify that there is recorder paper in the recorder.

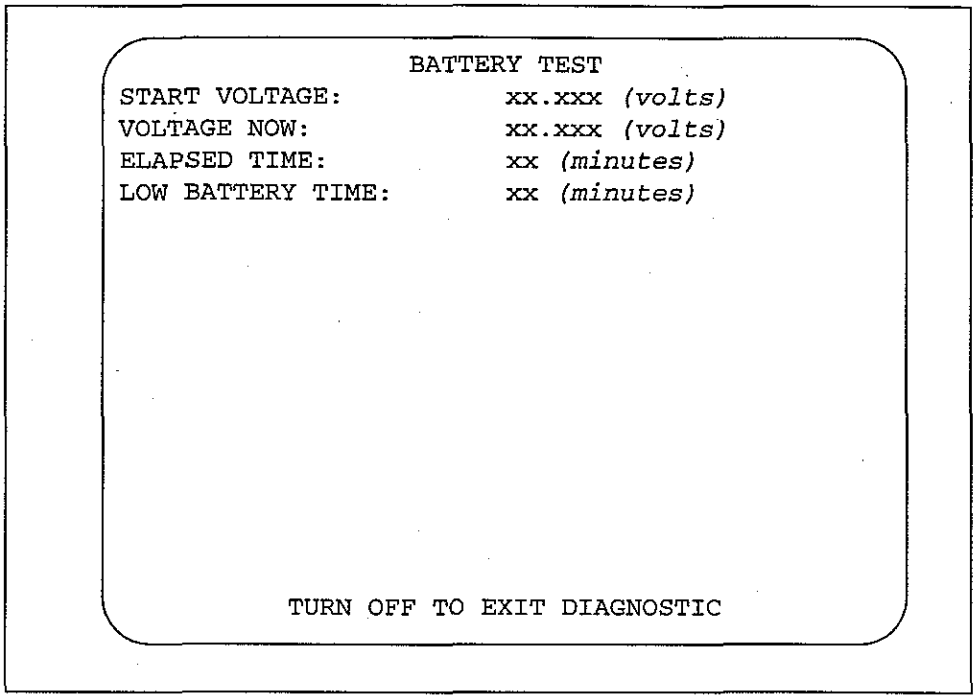
3 While pressing the (Sync) and (HR Alarm) keys, turn the Energy Select control from the **Off (Standby)** position to the **Monitor On** position. The setup/diagnostic menu appears after a moment.

4 Unplug the instrument from AC power (the (AC POWER) and (BATT CHRG) lights go off).

5 Press (▼ECG Size▲) to highlight TEST BATTERY.

6 Press (Lead Select) to start the Battery Capacity Test. The monitor displays the information shown in Figure 3-10.

Figure 3-10


BATTERY TEST
START VOLTAGE: xx.xxx (volts)
VOLTAGE NOW: xx.xxx (volts)
ELAPSED TIME: xx (minutes)
LOW BATTERY TIME: xx (minutes)
TURN OFF TO EXIT DIAGNOSTIC

Battery Capacity Test

START VOLTAGE:	The battery voltage when the test started.
VOLTAGE NOW:	The battery voltage at the present time.
ELAPSED TIME:	The elapsed time since the test started. The time includes the LOW BATTERY TIME.
LOW BATTERY TIME:	The length of time that the battery has been below the low battery warning level.

7 When the battery voltages reaches a low level, the Shutdown Warning tone sounds and the recorder prints out the final values of the displayed results just prior to turning off the instrument.

8 Replace the battery if the recorded value for ELAPSED TIME is less than 150 minutes (2.5 hours) or the value for elapsed LOW BATTERY TIME is less than 10 minutes.

9 Turn the Energy Select control to the **Off (Standby)** position.

10 Fully recharge the battery by plugging the instrument into AC power for 18 hours. Verify that the (AC POWER) and (BATT CHRG) lights are on.

11 The instrument is now ready to be returned to service.

Pacer Test (Option—XL+ Only)

This test verifies the pacer output level.

Test Prerequisites

A test load (HP M1781A) is required.

Testing the Pacer

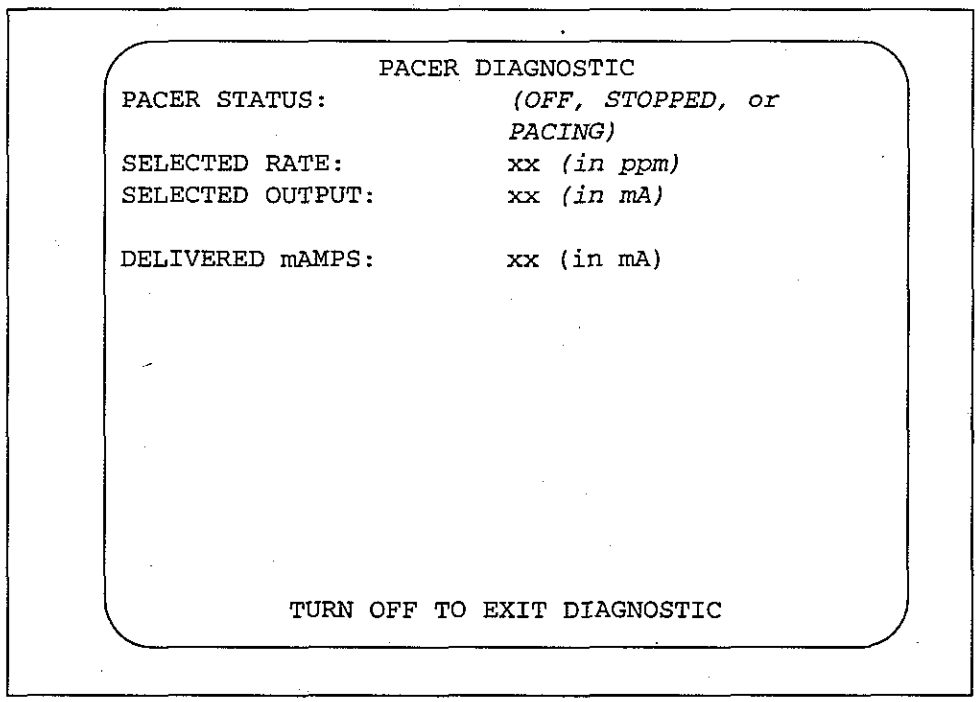
Follow these steps to perform the pacer test:

1 While pressing the (Sync) and (HR Alarm) keys, turn the Energy Select control from the **Off (Standby)** position to **Monitor On**. The setup/diagnostic menu appears after a moment.

2 Select TEST PACER on the setup/diagnostic menu.

3 Press (Lead Select) to select the Pacer test. The monitor displays the information shown in Figure 3-11.

Figure 3-11


PACER DIAGNOSTIC
PACER STATUS: (OFF, STOPPED, or PACING)
SELECTED RATE: xx (in ppm)
SELECTED OUTPUT: xx (in mA)
DELIVERED mAMPS: xx (in mA)
TURN OFF TO EXIT DIAGNOSTIC

Pacer Test

PACER STATUS	Shows whether the pacer function is turned off, is turned on but is not pacing (STOPPED), or is pacing (PACING). The (Pacer On) key turns the pacing function on and off; pacing can be turned on and also be stopped. (PACER STATUS may also show NO PADS or PADS OFF momentarily after START is pressed.)
SELECTED RATE	Indicates the current output rate, in pulses per minute, as selected by the pacer (▼ Rate ▲) key.
SELECTED OUTPUT	Shows the current output level, in mA, as selected using the pacer (▼ Output ▲) key.
DELIVERED mAMPS	Indicates the output level of the delivered pulses as measured by the defibrillator, in mA.

4 Connect the test load (HP M1781A).

5 Press (Pacer On) once, to turn on the pacer function. The indicator in the key should turn on; PACER STATUS should say STOPPED.

6 Press (▼ Output ▲) to increment the pulse output to the desired level. The current level is displayed on the screen.

7 Press (Start/Stop) to start pacing. PACER STATUS should say PACING.

8 Check that the DELIVERED mAMPS on the display is within these specifications:

Output Level	DELIVERED mAMPS
≤50 mA:	±5 mA
>50mA:	±10%

Printing the System (Error) Log

When an error occurs during normal operation, an error code associated with the error is stored in memory in the error log. Selecting PRINT LOG in the setup/diagnostic menu prints the stored error log. To decipher an error code on the printout, refer to the error lists in Chapter 5, **Troubleshooting**. Store the error log printout with the defibrillator's permanent maintenance record.

When the printout is complete, you can select another test from the setup/diagnostic menu.

Preventive Maintenance

Routine maintenance for the defibrillator consists mainly of cleaning and inspection.

CAUTION

The defibrillator does not require any kind of lubrication. Lubricating any part of the defibrillator could damage it or diminish its performance.

Care and Cleaning

The defibrillator and its accessories are chemically resistant to common cleaning solutions and non-caustic detergents. The following list includes some approved cleaning solutions.

- 90% Isopropyl alcohol (except adapters and patient cable)
- Soap and water
- Chlorine Bleach (30ml/l water)

NOTE

Keep the outside of the instrument clean and free of dust and dirt. Clean the paddles thoroughly to prevent build-up of dried electrolyte paste.

CAUTION

Do not allow any fluids to penetrate the instrument case. Avoid pouring fluid on the unit while cleaning.

Do not use abrasive cleaners, or strong solvents such as acetone, or acetone-based compounds.

Clean the display screen carefully. It is especially sensitive to rough handling and is subject to scratching.

Do not steam-sterilize the monitoring leads, submerge them for prolonged periods, or heat them above 50°C. If metallic surfaces become oxidized, clean them with a very light abrasive (toothpaste). Do not use highly abrasive cleaners, such as steel wool or silver polish.

Do not steam- or gas-sterilize the external paddle set.

Cleaning and Sterilizing the Internal Paddles

Although internal paddle sets are constructed using the highest quality materials, the severe conditions of steam sterilization will limit their useful life. Hewlett-Packard Company provides the standard, 90-day *consumables* warranty on the paddles. Since the useful life of these paddles is limited, replace them when functionality or appearance is questionable. When using the sterilization procedures described in this manual, the paddles will withstand approximately 200 sterilization cycles. This number will vary, depending on the equipment and process used.

- Clean the electrode surface and handle with common cleaning solutions such as Isopropyl alcohol, soap and water, or chlorine bleach (30 ml/water).
- Do not use acetone, enzymatic cleaners, ammonia-based cleaners or strong alkaline cleaners.
- Use a small, soft brush with cleaning solution to clean any contamination from the electrode surface and edges.
- Before sterilizing, clean any excessive residue which accumulates on the handles or electrode surfaces.
- Do no immerse the connector in cleaning solutions

Internal paddle sets can be sterilized using any of four different methods. Three of these methods use steam sterilization, the fourth method uses Ethylene Oxide (EtO). Although the internal paddle sets are constructed using the highest quality materials, the severe conditions of steam sterilization will limit their useful life.

Steam Sterilizing the Internal Paddles

Prevacuum Sterilization

Preparation	Double wrapped in sterilization grade wrap
Exposure Temperature	132–135°C (270–275°F)
Exposure Time	3 minutes

Flash Sterilization

Preparation	Unwrapped
Exposure Temperature	132–135°C (270–275°F)
Exposure Time	3 minutes

Gravity Sterilization

Preparation	Double wrapped in sterilization grade wrap
Exposure Temperature	121–123°C (250–254°F)
Exposure Time	30 minutes

Ethylene Oxide Sterilization

Temperature	54°C ± 1°C (130°F ± 2°F)
Relative Humidity	60% ± 20%
EtO Concentration	600 mg/L ± 30 mg/L 12/88 EtO
Exposure Time	1 hour 45 minutes
Aeration Time	18 hours

Cleaning the Printhead and Paper Sensor

If the recorder printing is light or varies in density, clean the printhead to remove any possible buildup of paper residue.

To clean the printhead:

1 Slide the recorder door toward the right side of the defibrillator until the paper platen tilts up.

2 Pull up on the plastic removal tag to remove the paper roll.

3 Clean the printhead surface (above the rubber pinch roller) with rubbing alcohol and a cotton swab. See Figure 3-12.

4 Re-install the paper roll.

5 While holding the recorder door open (to the right), press the platen down to its normal (closed) position.

6 Release the recorder door, allowing it to close over the platen.

To clean the paper sensor lens:

1 Slide the recorder door toward the right side of the defibrillator until the paper platen tilts up.

2 Pull up on the plastic removal tag to remove the paper roll. The paper sensor lens is to the right under the printhead (see Figure 3-12).

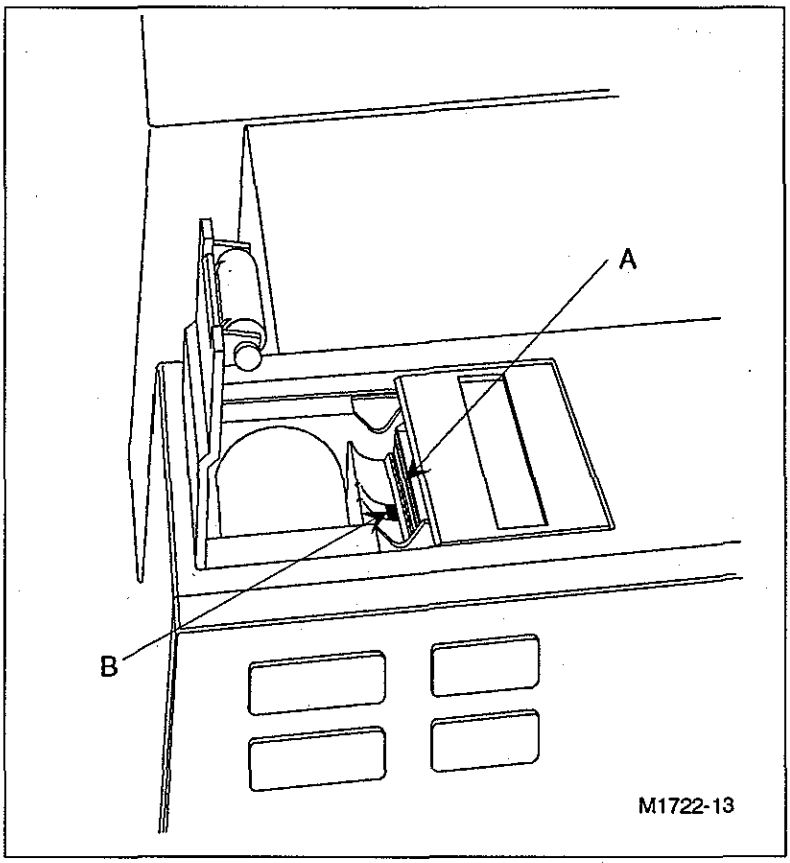
3 Lightly wipe the paper dust off of the paper sensor lens with a dry foam swab.

4 Re-install the paper roll.

5 While holding the recorder door open (to the right), press the platen down to its normal (closed) position.

6 Release the recorder door, allowing it to close over the platen.

Figure 3-12



Cleaning the Printhead or Paper Sensor

A. Printhead
B. Paper Sensor

Safety Tests

The safety tests listed below are performed at the time of manufacture to assure compliance with these standards: IEC 601-1, IEC 601-2-4, UL 544, and CSA 22.2 No. 601.1.

- Chassis-to-ground resistance
- Ground wire leakage current
- Enclosure leakage current
- Patient lead leakage current (source leakage) to ground
- Leakage current between patient leads
- Patient lead leakage current (sink current) with line voltage applied

These tests should be part of your preventive maintenance program, and should be performed after any corrective maintenance to assure continued compliance with the named standards.

To perform these tests, use commercially available safety testers or analyzers designed specifically for this purpose. Follow the manufacturer's operating instructions for hookup and test procedures.

Defibrillator Checklist

Model number _____
Serial number _____
Test date _____
Test technician _____

Visual Inspection

Disconnect the defibrillator from AC power and inspect for the following:

- ❑ Loose or missing hardware.
- ❑ Frayed or damaged wiring.
- ❑ Mechanical damage.
- ❑ Evidence of liquid spill.
- ❑ Recorder drive gear wear.
- ❑ Recorder roller wear.
- ❑ Wear or damage to power cord and associated strain relief.
- ❑ Corroded or damaged electrodes.
- ❑ Damaged adaptors or patient cables.
- ❑ Dirt on the thermal printhead

Connect the defibrillator to AC power and verify the following:

- ❑ The (AC POWER) and (BATT CHRG) indicators are lit.
- ❑ The (Charge) and (Sync) indicators light momentarily, when you turn the Energy Select control to **Monitor On** to turn on the defibrillator.

Performance Tests

Charge Energy Level

- ❑ Delivered Energy Level Test

Pacer

- ❑ Pacer Test (Option—XL+ only)

SpO_2

❑ SpO_2 Test (Option)

ECG Simulation

Record an ECG using an ECG simulator. Verify the following:

❑ Trace activity for all leads.

❑ No gross distortion of complexes or calibration pulses.

❑ Calibration pulses are of proper duration (200 ms) and amplitude (1 mV).

The trace will vary depending on simulator settings used and simulator type. Calibration pulse measurements will vary depending on the defibrillator gain.

Setup/Diagnostic Menu Tests

Run the battery capacity test, and verify that the test passes within limits. The other setup/diagnostic menu tests can be performed as additional checks.

❑ Defibrillator Test

❑ ECG (Monitor) Test

❑ CRT Test

❑ Recorder Test

❑ Controls Test

❑ Indicators Test

❑ Battery Test

❑ Pacer Test

Print out the system (error) log. Store the printout with the defibrillator's permanent maintenance record.

Print out the setup menu settings. Store the printout with the defibrillator's permanent maintenance record.

Comments:

Theory of Operation

Introduction

This chapter provides theory of operation for the M1722A/B and M1723A/B Defibrillators. The theory describes at a high level the functional operation of the major electronic assemblies (listed below) that make up the defibrillator.

- Control board
- Power supply
- High voltage board
- Patient circuit
- ECG front end board
- CRT module
- Pacer board
- SpO_2 board
- Main keypanel board
- Pacer keypanel board
- Recorder module

These are the primary field-replaceable assemblies. For a complete listing of repair parts available for field repair, refer to Chapter 7, **Parts Lists.**

Circuit References

Components are usually referred to by the component's function (such as the Defibrillator processor). References more specific than that are to individual diagrams that accompany the text.

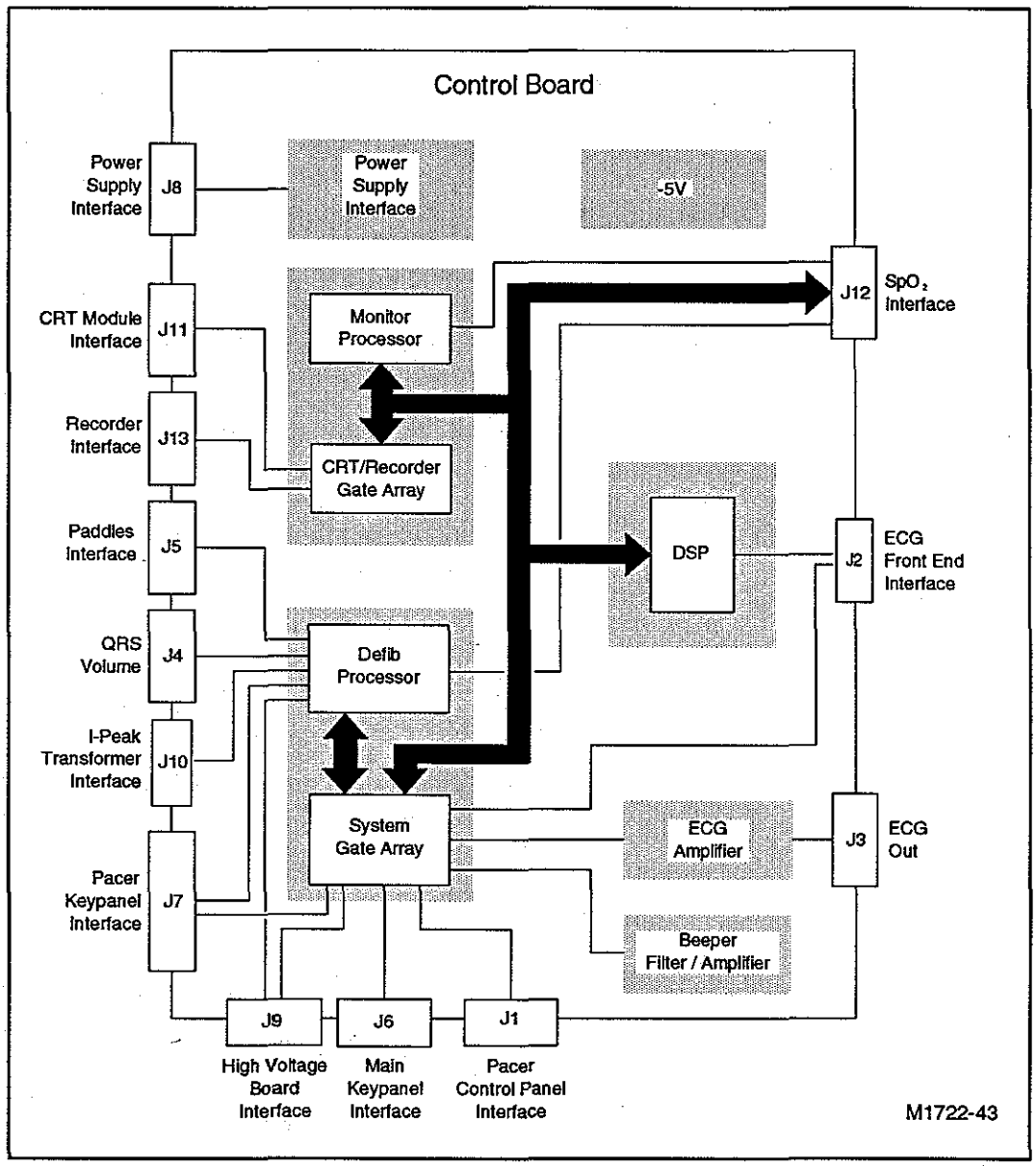
With a few exceptions, the only signal names used in this theory description are those that pass between the boards. Appendix A provides signal descriptions for each connector. Some signal names are prefixed with a letter that indicates what kind of signal it is. While this is not always true, you can usually assume the following:

c Connector Signals. These have been conditioned for EMI purposes.
f Filtered Signals. These signals have been low-pass-filtered to minimize the high frequency components that they would otherwise contain.
n Active Low.
p Pulsed signals (except for clocks, which usually have 'clk' embedded in their names).

Control Board

The control board provides the processing power to run the defibrillator and supplies a central interconnect for other parts of the instrument. Three processors are supported on the control board: an 80960KA (the Monitor processor), a μPD77C25 (Digital Signal processor–DSP), and an 80C196KC (the Defibrillator processor). These processors are connected to one another and to peripheral devices through two CMOS gate arrays, the System gate array and the CRT/ Recorder gate array. Figure 4-1 shows the functional groupings and their basic interconnections.

Figure 4-1



Control Board Block Diagram

The control board performs a variety of individual functions that fall into three major functional groups, each centered on one of the three processors. Other functions on the control board include the power supply interface and three analog functions.

Defibrillator Processor Functional Group

The Defibrillator processor handles the keyboard and indicator interface, system monitoring, and, with the System gate array, defibrillation control.

Defibrillation Control

Defibrillation control includes the charging and discharging operations.

Charging

The Defibrillator processor detects the closure of the paddles charge key, finback, at one of the processor's direct analog inputs, or it detects the closure of the front panel charge key, fnCHARGEKEY, by reading its value from the System gate array. After a debounce time, the key closure is considered valid and the processor begins a charge operation. The level of charge is determined from the value of four bits from a grey-coded rotary switch (fENSEL0, 1, 2, and 3) (also read from the System gate array).

Before charging begins, the Defibrillator processor instructs the System gate array to open the safety relay, which is located on the high voltage board. The System gate array asserts fOPNSFRLY (open safety relay), which commands the high voltage board to remove the 47 kΩ safety resistor that is normally across the High voltage capacitor.

A charge operation begins when the Defibrillator processor instructs the System gate array to assert the logic signal fnCHGEN and give the analog signal fCHRATE a non- zero value. These signals go to the high voltage board, which begins charging at the specified rate. While the charging proceeds, the Defibrillator processor monitors the energy present in the High voltage capacitor by sampling the capacitor voltage, fVCAP.

When the processor is satisfied that the proper energy is stored in the High voltage capacitor, it turns the charger off by placing a zero value on the fCHRATE line, and de-asserting fCHGEN. As charge bleeds off the High voltage capacitor, the processor will periodically request refresh charges from the charging circuitry. If the requested charge is lowered, the safety relay is used to bleed off charge to the lower level.

Discharging

A shock request occurs when both the Sternum and Apex Shock keys are closed, asserting fnDISCHGS and fnDISCHGA. These two signals are "NORed" to generate fHVDISCHG which is routed to both the Defibrillator processor and the high voltage board (for redundancy purposes).

The Defibrillator processor performs the shock operation by issuing a shock request command to the System gate array. When this happens, the System gate array takes over. It begins a waiting period (approximately 1 msec.) that allows the processors to prepare to be reset. When the waiting period is over, all processors are reset. The System gate array then asserts fPRDRV, which when combined with fHVDISCHG, closes the patient relay. Once the patient relay is closed, only fPRDRV true is required to keep it closed. The safety relay is also closed (fOPNSFRLY is de-asserted) when the fPRDRV line is asserted.

When the shock reset time is over (approximately 80 msec from shock initiation), the system gate array releases all processors from reset. All processors then perform post-shock initialization and resynchronize communication paths. At 300 msec from shock initiation, the defibrillator processor opens the patient relay, thus terminating the shock sequence

System Monitoring

The Defibrillator processor monitors a variety of system functions. Some of these are read directly by the processor at its analog inputs, while others are first preselected using an analog multiplexer. The direct measurements are:

Capacitor voltage	A sample of the voltage across the High voltage capacitor (VCAP). Used to determine the energy stored in the capacitor. One volt at the A/D equals 1144 volts at the H.V. capacitor.
QRS volume control	Reads the value of fQRSCNTL to set the volume level of the QRS tone. fQRSCNTL varies between 0 and approximately 3 V depending on the setting of the QRS volume control.
Printhead temperature	Reads the value of fTSENSE, an analog signal generated by a temperature sensor on the recorder. Used to vary the duty cycle for printhead write in response to changes in printhead temperature.
Head resistance	The recorder board encodes printhead resistance into a voltage (fCAL). The Defibrillator processor converts fCAL to a digital signal used by the Monitor processor to set the duty cycle for printhead writes.
Paddles identification	The Defibrillator processor reads the voltage value on the fPADID line to determine the type of paddles connected to the instrument. Table 4-1 lists the voltage levels for the paddles types.

Table 4-1 **PADID Voltage Value vs. Paddles Type**

fPADID	Paddles Type
< 0.5 V	Internal Paddles
≥0.5, < 3 V	External Paddles
≥3.0, < 4 V	External Pads
≥4.0 V	None

The multiplexed measurements are:

Peak current	The Defibrillator processor reads the value on the SIPEAK line, which is a sample of the peak discharge current delivered to a patient. One volt at the A/D converter indicates 20.5 amperes of peak current.
Pacer current	The pacer current is sampled on the pacer board and delivered to the control board on the fPACMES line.
Supply voltages	The control board monitors the following voltages: • Battery (VBATT) • +12 V (12V) • +5 V (5V) • +VDC (VDC2)
Defibrillator status	The Defibrillator processor reads fDEFIBSTAT, an analog signal generated by the high voltage board to provide status information. Normally, the status is "good" when fDEFIBSTAT is >2.5 V, and "error" when ≤2.5 V. Immediately following a shock (while the patient relay is still closed) status is "good" when fDEFIBSTAT is <1.0 V, "error" when ≥1.0 V.

Keyboard and Indicator Interface

The Defibrillator processor performs most of the keyboard and indicator functions through the System gate array. For keyboard functions, this is implemented with a parallel register set. The Defibrillator processor debounces keys, which are then saved in the System gate array. In the System gate array, both the Defibrillator and Monitor processors can access the debounced key registers.

Similarly, output drive for the LED indicators comes from a parallel port (controlled by the Defibrillator processor). These outputs drive emitter followers, which provide the current drive required by the LEDs.

All key lines are filtered for EMI. The filters also provide some protection to the inputs of the gate array.

The energy select switch is treated differently. It uses a 1 kΩ pull-up resistor to provide more current for switch contact reliability.

The Monitor Processor Functional Group

The Monitor processor (an 80960KA processor) handles central processing, and with the CRT/Recorder gate array, display control and recorder control. The Monitor processor also handles the interface with the Option Slot.

Central Processing

The main processing power of the system consists of the Monitor processor, its decoding and demultiplexing logic, ROM, and RAM. The CRT/Recorder gate array provides clocks and various control signals to these parts. The Monitor processor operates at 8 MHz (clk2 equals 16 MHz).

System ROM consists of two 64Kx16 or 128Kx16 devices which are socketed; system RAM consists of four 128Kx8 devices. System RAM and the RAM interface to the processor are backed up by battery to ensure that data is not lost during power-up or power-down. The real-time clock circuitry is also backed up by the battery.

The Monitor processor communicates with the Defibrillator processor and the real-time clock through the System gate array. The System gate array also provides four levels of Monitor processor interrupts.

Display Control

The CRT/Recorder gate array interfaces the Monitor processor to the display. The gate array generates the necessary strobes to support a fixed-plane 256Kx4 VRAM and a moving-plane 256Kx4 VRAM, and provides video and sync information for the CRT. Both full-bright and half-bright information is provided to the CRT. The gate array also allows the Monitor processor to randomly read and write VRAM.

Recorder Control

The CRT/Recorder Gate Array also interfaces the recorder to the Monitor processor. The recorder requires four 384-bit serial data streams every 5 ms. Because of the very high overhead that would be required for the processor to do this directly, the CRT/Recorder gate array converts this to 48 32-bit accesses (performed via DMA) from system RAM. The CRT/Recorder gate array also generates the appropriate motor control strobes to operate the recorder stepper motor. These motor control strobes are pulse-width modulated at 32 kHz to reduce motor current consumption.

To maximize printhead life and reliability, an electronic power switch turns off the supply voltage when the recorder is not in use. The power switch is an FET with very low on-resistance and is turned on or off by processor command.

Interface to the Option Slot

The Monitor processor interfaces to the option slot through J12. This interface consists of an 8-bit address/data bus with associated strobes for direction and timing control. The option slot interface includes two reset lines, nERAWRST and nPRST, from the control board, and three interrupts from the option slot. Supply voltages available to the option slot are +5 and +12 from the main power supply, and +DIGBACKUP from the digital backup supply on the control board.

The optional SpO_2 board uses the option slot.

Digital Signal Processor

The uPD77C25 Digital Signal Processor (DSP) handles digital signal processing of ECG front end information. The DSP and its supporting logic interface to the ECG front end serially using the signals fFESI, fFESO, fnFESENL, and fnFESENP. The DSP interfaces to the Monitor processor through the CRT/Recorder gate array.

Power Supply Interface

The power supply interface consists of four parts:

- Digital backup supply
- Power failure detector
- Switch A control
- LED drivers

Digital Backup Supply

VDC2 and VBATT are diode-ORed to form +VBACKUP. +VBACKUP passes through a low current regulator to generate a 4.3 V supply, +DIGBACKUP. This provides a power source whether on battery only or AC only. +DIGBACKUP powers the On/Off circuitry and VRAM.

Power Failure Detector

When the +5 V supply voltage drops below +4.65 V, this circuit generates nPF, a signal that interrupts both processors via the System gate array, and ≈8 ms later produces nRAWRST, the basic reset signal.

Switch A Control

Switch A is a solid-state FET switch in the power supply that connects the battery to VDC. When the defibrillator is connected to AC, Switch A closes to allow VDC to charge the battery. When the defibrillator is not connected to AC and the

instrument is turned on, Switch A closes to allow the battery to power the instrument. The Switch A control circuit generates fSWADRIVE, the drive signal for Switch A. fSWADRIVE closes Switch A under the following conditions:

- AC is present and the high voltage capacitor is not charging
- The defibrillator is on and the battery voltage is higher than the shutdown voltage (no AC)
- The battery is below the shutdown voltage but is charging the high voltage capacitor (no AC).

The Switch A control circuit includes part of the mechanism that shuts down the instrument when the battery gets too low. One minute after the Defibrillator processor detects that battery voltage has become too low, it instructs the System gate array to set a flip-flop in the Switch A control circuit. This turns off SWADRIVE to open Switch A and disconnect the battery. If the defibrillator is connected to AC, the instrument will continue to operate. If the defibrillator is not connected to AC, turning the energy select switch off and then on will restore operation for another one minute until the low battery condition again forces the instrument to shut down.

LED Drivers

One driver provides power to the battery charging LED when AC power is on and the battery is installed; the other driver provides power to the AC-on LED when AC power is on.

Miscellaneous Analog Functions

Miscellaneous analog functions performed on the control board are:

- I-peak measurement — A voltage winding in the Patient inductor samples discharge current. The I-peak measurement circuit integrates and peak-detects the sample to produce SIPEAK.
- –5 V generation — a voltage inverter converts +5 V to the low-current –5 V used by some of the operational amplifiers.
- ECG amplification — an AC-coupled voltage doubler that converts a CMOS-level pulse-width-modulated signal from the Defibrillator Gate Array into the 10 V peak-to- peak (+5 V to –5 V) signal required by the 1000:1 ECG output.
- Beeper filtering/amplification — filters and amplifies the TONE signal that comes from the System gate array. Provides a 12 V peak-to-peak signal to drive the beeper.

Power-Up/Down Processes

The following is a description of how the control board performs the powering-up and powering-down processes. It is assumed that the instrument is either plugged in to the AC mains or that a charged battery is installed. In either case, +VBACKUP is about +12 V and +DIGBACKUP is at +4.3 V.

OFF State

When the energy select switch is in the off position, the fnON signal line is pulled high. This tells the power supply to not generate any of its regulated voltages. Consequently, +5 V is near ground and the power-fail detector holds the power-fail signal (nPF) low and generates nRAWRST. nRAWRST is the reset signal that generates most of the other reset signals.

Power-Up

When the energy select switch is moved from its off position, fnON is shorted to ground. This tells the power supply to start generating its regulated voltages. When the 5V supply reaches +4.72V, nPF goes high. About 450 ms later, nRAWRST also goes high.

nRAWRST going high tells the gate arrays to begin generating clocks and to start their exit from reset processes. When all the resets are released, the Monitor processor performs its boot-up and tries to establish communications with the Defibrillator processor via the System gate array.

The Monitor processor does a self-check when it comes out of reset. When first released from reset, the Monitor processor drives the nFAILURE line low. It then performs a series of internal checks. If the results are satisfactory, it releases the nFAILURE line. The processor then fetches the first eight words from memory (ROM) and performs a checksum on the results of the fetch. If the checksum is correct, the processor continues. If not, the nFAILURE line is again driven low and the processor halts operation. By watching the nFAILURE line as the processor comes out of reset, you can determine whether the processor is functioning internally and whether its connection to ROM is functioning.

Power-Down

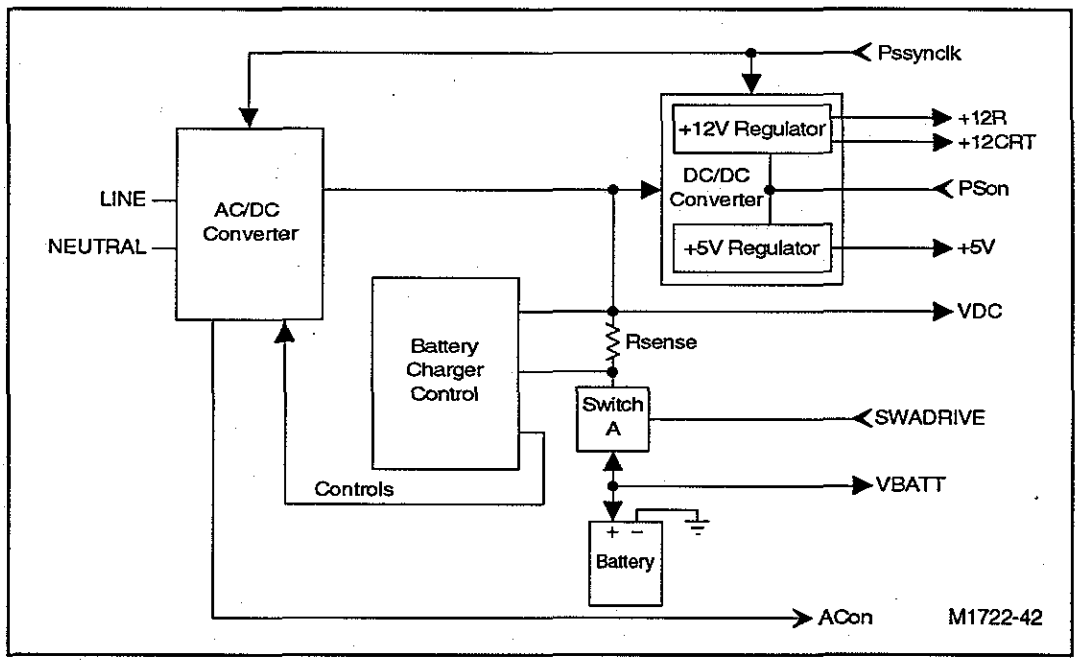
A power-down sequence is initiated by the power-failure detector. When the energy select switch is moved to its off position or +5 V supply drops below +4.65 V, the power-failure detector asserts nPF (the power fail signal). This signal is routed to the System gate array, which then drives a power- fail interrupt to both the Monitor and Defibrillator processors. These interrupts tell the processors that they have 1 ms of power to accomplish any tasks that must be performed before they shut down. 8 ms after nPF occurs, nRAWRST is asserted

Power Supply

The power supply is a universal input supply that accepts 80 - 264 Vac input. It provides +5 and +12 volts to operate the defibrillator logic and display circuits, and approximately 13.5 volts (VDC) to charge the battery and power the high-voltage charger and recorder. The block diagram of the power supply is shown in Figure 4-2. This description of the power supply covers detail at the functional block level. The functional blocks that make up the power supply are:

- AC/DC Converter
- Battery Charger Control
- DC/DC Converter

Figure 4-2



Power Supply Block Diagram

AC/DC Converter

The first stage of the power supply is the AC/DC converter, a forward converter that supplies VDC (13.5 - 16.0 volts) to the DC/DC converter, the high voltage charger, and the battery (as the charging voltage).

Battery Charger Control

SWADRIVE (switch A drive) closes the FET switch between the battery and the AC/DC converter supplying VDC, when the instrument is powered by the battery only. When the instrument is turned on, switch A is closed to provide battery voltage to the DC/DC converters primary side.

Switch A is also closed when ACON is true (AC is on) and the instrument is off, in order to charge the battery. Rsense is a bank of resistors used to sense the amount of current being delivered to the battery when it is being charged. When the battery supplies the system, however, Rsense is bypassed in the battery charger control circuitry. The battery charger is a three state charger and is temperature compensated. The following list details the three states.

1 Current limit; charges the battery at 1.60 A rate until charge voltage reaches the overcharge voltage.

2 Over charge; charges at a voltage greater than Vfloat (nominal charge voltage), V- overcharge ≈ 14.5 V @ 25°C).

3 Float voltage; charges the battery at Vfloat (13.6 V @ 25°C) when charging current is less than 120 mA.

DC/DC Converter

When the instrument is turned on, the DC/DC converter provides +12 and +5 output voltages from an input voltage range of 9.0 Volts (lowest battery voltage under Defibrillator charge) to 16.0 volts (highest VDC) using a flyback converter. The DC/DC converter is powered by the AC/DC Converter at all times unless operating on battery only.

Efficiency of the DC/DC converter is specified at 80% and is optimized for greatest efficiency at nominal load.

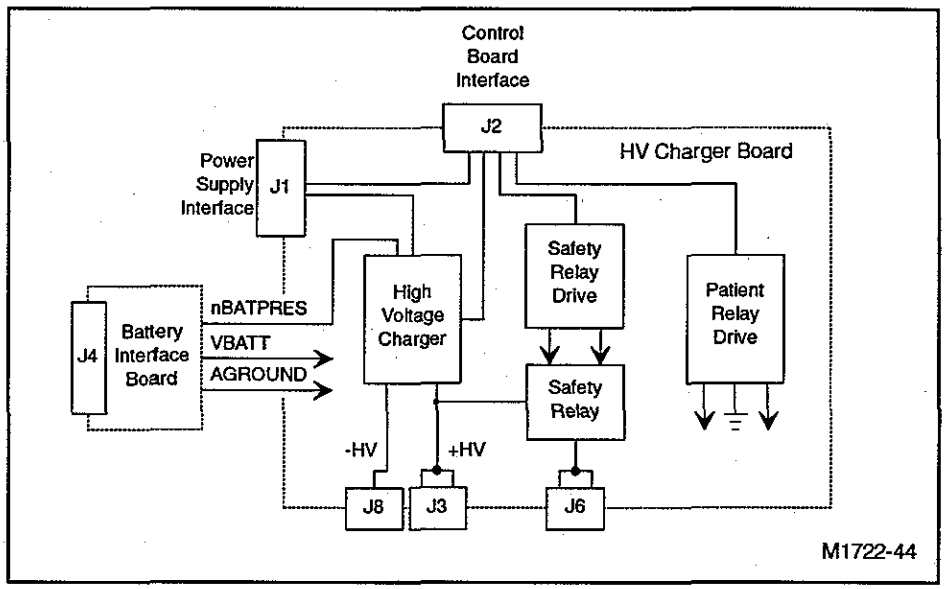
High Voltage Board

The following circuits make up the high voltage board:

- Battery connector
- Safety relay drive
- Patient relay drive
- High voltage charger

These circuits are shown in Figure 4-3.

Figure 4-3



High Voltage Board Block Diagram

Battery Connector

The Battery Connector board is a small circuit board that connects the lead acid battery to the defibrillator. Fuse F1 (located on the Battery Connector board) protects the battery from inadvertent instrument shorts. Power is routed to the high voltage board via cable assemblies P3 and P4. Battery voltage is then routed through the high voltage board to the power supply via connector J1.

Safety Relay Drive

The safety relay is normally closed and opens when control signal OPNSFRLY is true. As described earlier, this relay must open before the high voltage capacitor can charge. When a defibrillation discharge occurs, the safety relay closes simultaneously with or up to 10 ms before the patient relay closes. The safety relay circuit will then disarm the capacitor on an open paddles discharge.

Patient Relay Drive

The patient relay switches high voltage to allow a defibrillator shock. For this to occur, both shock switches must be pressed to assert the signal DISCHRG, *and* the Defibrillator processor must issue the shock command PRDRV (patient relay drive), which activates the patient relay. The Defibrillator processor monitors the status of the discharge control circuitry by reading fDEFIBSTAT. The Defibrillator processor can then display the appropriate error message in case of a fault. Error messages are explained in Chapter 5, **Troubleshooting**.

High Voltage Charger

The high voltage charging circuit charges the High voltage capacitor by means of a variable frequency, high-voltage flyback DC/DC converter. When the charging circuit is at room temperature and powered by a fully charged battery, 'fast charge' occurs. In this mode the defibrillator can charge to 360 joules in under five seconds. When at room temperature but powered by AC only (battery not installed), 'normal charge' occurs. In this condition the instrument will charge to 360 joules in less than 15 seconds. The charging of the High voltage capacitor is electrically isolated from grounded portions of the instrument.

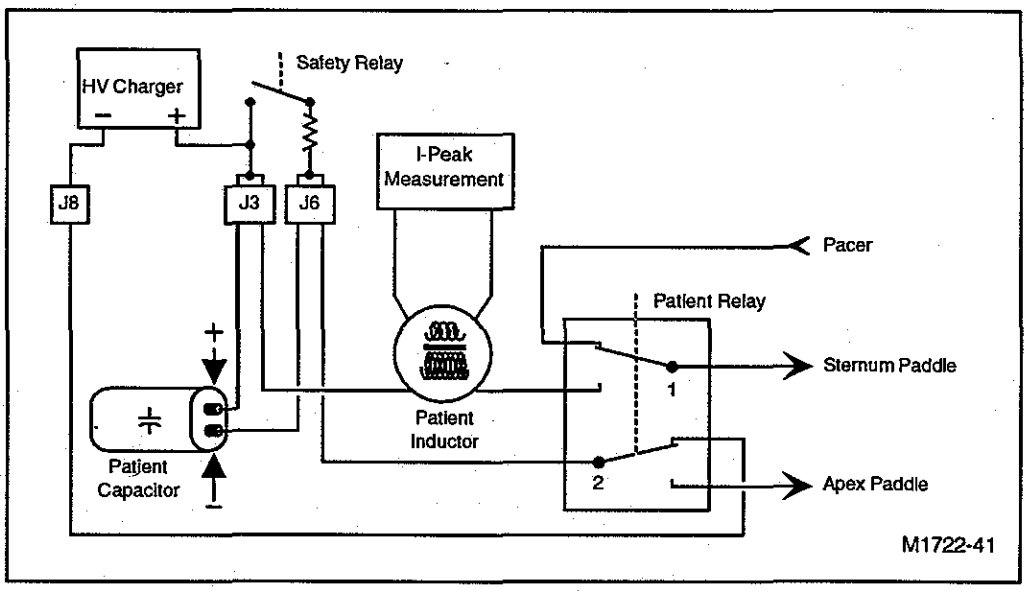
A charge begins when the signals OPNSFRLY, nCHGEN, *and* CHRATE are asserted. When the High voltage capacitor reaches the proper energy setting, the Defibrillator processor de-asserts the signals nCHGEN, and CHRATE to stop the charge.

Patient Circuit

The patient circuit (shown in Figure 4-4) consists of the following components:

- High voltage capacitor (35 µF, 5.1 kV)
- Patient inductor/Ipeak Transformer (50 mH, 11 Ω)
- Patient Relay (Double-pole, Double-throw Mechanical Relay)
- Coil Cords, Connectors, and Discharge Paddles
- Safety Relay (Single-pole, Single-throw Mechanical Relay)
- Patient Load (either a patient or the internal 50 Ω test load resistor)

Figure 4-4



Patient Circuit Block Diagram

The High voltage capacitor, Patient inductor, and patient load form a series-resonant LC circuit with a critical damping load resistance of 63 Ω. For a nominal patient load of 50 Ω, the discharge waveform is a slightly underdamped sinusoidal waveform.

The High voltage capacitor is charged up by the High Voltage Charger to the voltage required for any of the various energy settings, which range from 2 to 360 Joules (actual voltage on the High voltage capacitor ranges from 325 V and 5300 V).

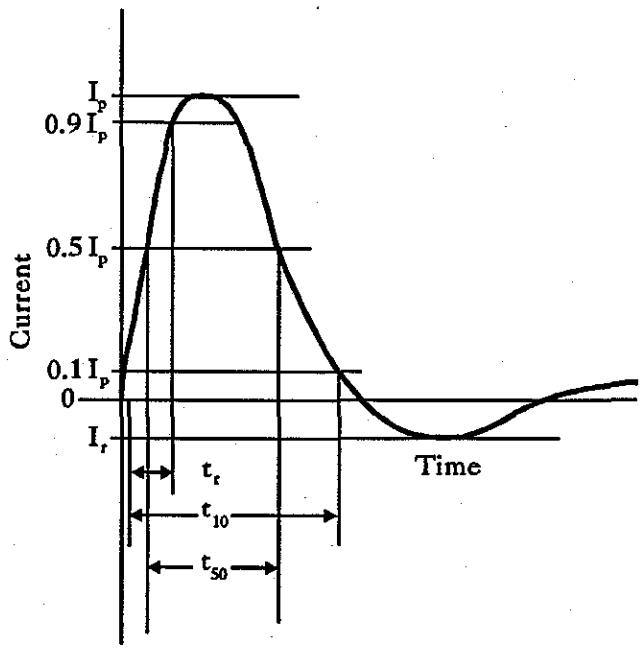
This capacitor is then discharged through the Patient inductor and the patient relay into the patient load.

During a shock, the patient relay isolates the patient circuit and capacitor from one side of the pacer circuit to prevent the pacer from absorbing energy from the delivered pulse, and isolates the high voltage charger from the capacitor to protect the charger from reverse polarity during waveform undershoot. The waveform characteristics of the pulse delivered through resistive loads of 25, 50 and 100 ohms is shown in Figure 4-5 and Table 4-2.

The Patient inductor has a secondary winding that develops a voltage during discharge. This voltage is integrated and peak-detected on the high voltage board to determine the peak discharge current, Ipeak. The coil cords carry the discharge current to the paddles and patient load, and also carry control signals to and from the paddles. The coil cords contain shielding to lower the RFI sensitivity of the high voltage discharge wires so they can also be used as low-noise sensing wires for the paddles ECG circuit on the ECG front end board.

The Safety relay is in series with a 47 kΩ resistor and both are located on the high voltage board. This circuit slowly discharges the capacitor when its energy is not needed but still present (i.e. aborted shock). This circuit also bleeds off part of the charge if the user selects an energy setting, the defibrillator charges to that setting, and then the user selects a lower energy setting.

Figure 4-5



Damped Sinusoidal Waveform Parameters

Table 4-2 **Specifications for Damped Sinusoidal Output Waveforms**

	Local Resistance		
Waveform Parameter	**25 Ohms**	**50 Ohms**	**100 Ohms**
I_p (amperes)	$96\alpha \geq I_p \geq 55\alpha$	$66\alpha \geq I_p \geq 45\alpha$	$46\alpha \geq I_p \geq 25\alpha$
I_r (amperes)	$38\alpha \geq \lvert I_r \rvert \geq 0.0$	$18\alpha \geq \lvert I_r \rvert \geq 0.0$	$4.0\alpha \geq \lvert I_r \rvert \geq 0.0$
t_r (ms)	$1.60 \geq t_r \geq 0.50$	$1.42 \geq t_r \geq 0.40$	$1.25 \geq t_r \geq 0.30$
t_{50} (ms)	$4.60 \geq t_{50} \geq 2.0$	$4.17 \geq t_{50} \geq 2.10$	$6.40 \geq t_{50} \geq 2.30$
t_{10} (ms)	$6.90 \geq t_{10} \geq 3.0$	$9.20 \geq t_{10} \geq 3.10$	$19.60 \geq t_{10} \geq 4.00$

I_p Peak current of the waveform

$|I_r|$ Absolute value of the reverse current of the waveform

α $\frac{E}{360}$ and E is the selected energy that would be delivered to a 50-ohm resistive load

t_r 10% to 90% risetime of the first lobe of the current waveform

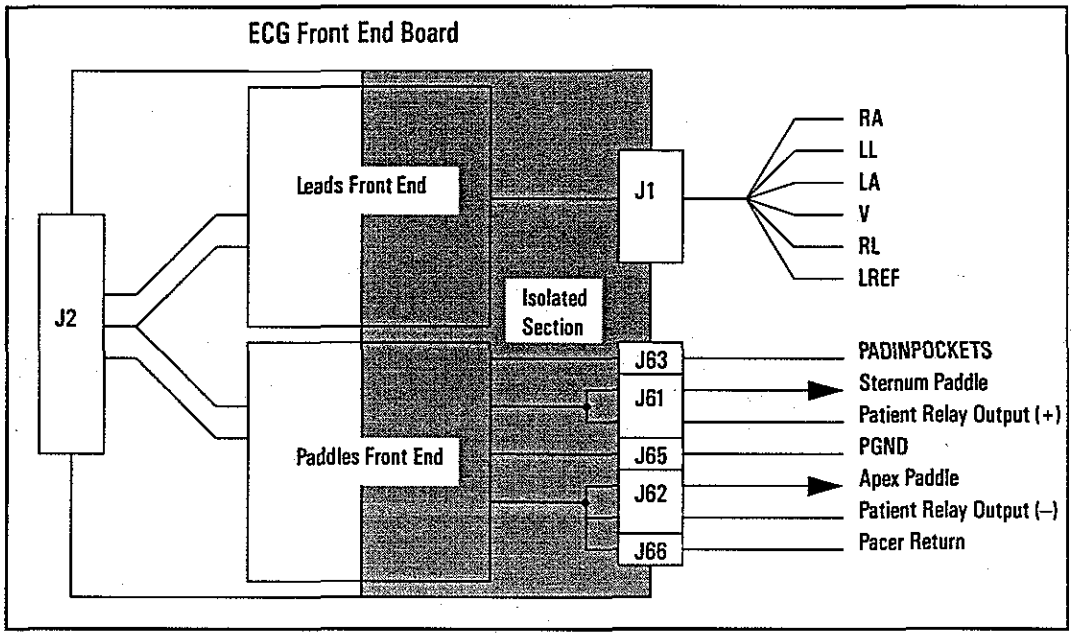
t_{50} Waveform width associated with the 50 percentage points of the first lobe of the current waveform

t_{10} Waveform width associated with the 10 percentage points of the first lobe of the current waveform

ECG Front End Board

Two separate and isolated front ends constitute the ECG front end board as shown in the block diagram in Figure 4-6. The first is a two-wire paddles ECG amplifier, and the second is a five-wire leads front end. The paddles front end operation is nearly identical to the leads front end operation. The design for both front ends is based on a Hewlett-Packard custom front-end IC. The paddles front end also includes functions for paddles-in-pocket and pre-shock impedance (also called paddles contact impedance or PCI).

Figure 4-6



ECG Front End Block Diagram

Both front ends communicate with the Digital Signal Processor (DSP) located on the control board. The DSP processes the digitized data from both front ends simultaneously and provides data to the monitor processor.

Power Supplies

Each of the front ends has its own isolated power supply. The supply for the leads front end is enabled when the FELEN signal is true; the supply for the paddles front end is enabled when the FEPEN signal is true. A forward converter, which is clocked by FEPWRCLK, generates isolated power for the two front ends. The output of the converter is regulated to +5 volts. The supply also provides a 2.5-volt reference for use in biasing the front end IC.

Leads Input Protection

The leads are connected to the five input channels of the IC through a breakdown device (neon bulb) and a 2-pole LPF. The neon bulb is used as Defibrillator overload protection (current is limited by a 1 kΩ resistor in the lead set). The remaining voltage is dropped across 75 kΩ and the internal protection diodes of the IC.

Paddles Input Protection

The paddles inputs are subjected to defibrillator shocks, and therefore are designed to meet 8 kV breakdown from paddle-to-paddle. 100 kΩ high-voltage resistors in series with the ECG input limit the current sufficiently to allow the input protection diodes on the front end IC to handle the current. As part of the pre- shock impedance path, series resistors and capacitors are also high voltage devices. External diode clamps are added to this path, routing current away from the front end IC.

Cal Pulse

Internally generated signals allow for self-test and gain calibration.

Data Communication

Clocks and data are transmitted through opto-isolators across the isolation boundary. Data transmitted to the front end IC include control parameters such as gain, Right Leg Drive lead, etc. Digitized ECG data and status information is transmitted from the front end IC to the DSP chip on the control board.

Pre-Discharge Impedance

An indication of paddles contact is given on the bar graph located on the external paddles (PCI). Patient impedance (at 32 kHz) is measured by the paddles front end IC. This measured impedance value is used by the Defibrillator processor to determine the drive level to the PCI bar graph on the sternum paddle.

Paddles in Pocket

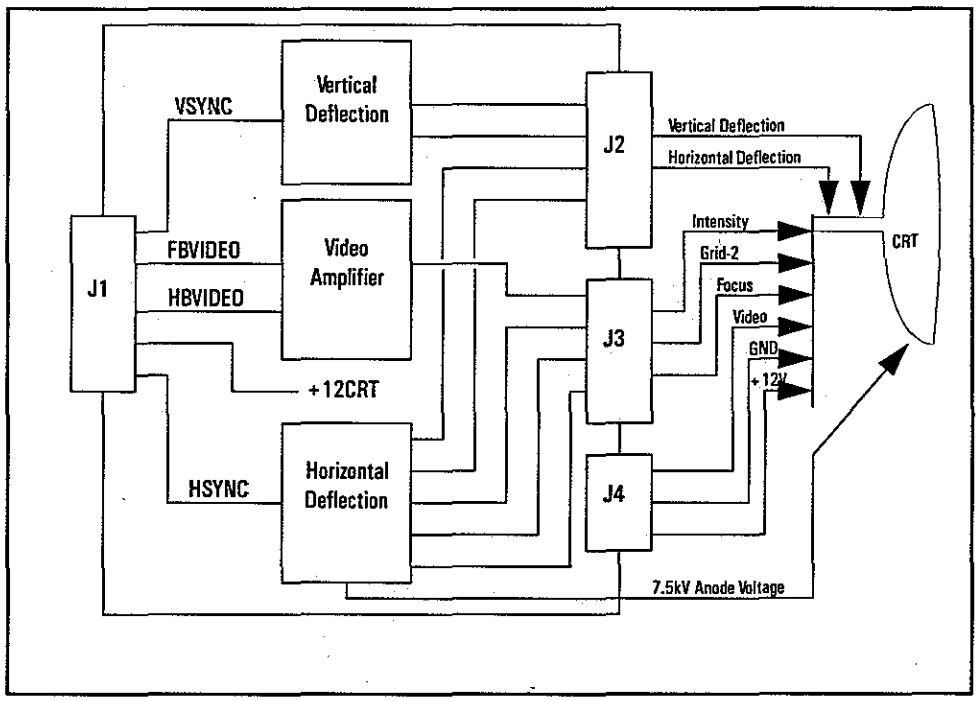
To detect paddles in pocket, the paddles front end IC applies a signal to the center tap of the 50 Ω test load resistor (the center-tap is connected to the paddles front end through connector J63). If this signal is detected on the Vapex and Vsternum inputs, the front end IC signals that the paddles are in the pockets.

CRT Deflection Board

The CRT deflection board (shown in Figure 4-7) performs these functions:

- Vertical deflection
- Horizontal deflection
- Video amplification
- CRT bias voltage generation

Figure 4-7



CRT Assembly Block Diagram

Signals entering the CRT deflection board from the control board are GND, VSYNC, VIDEO, CRT12V, and HSYNC.

The CRT displays information using a raster pattern. Total usable raster area is 832 dots horizontal, 256 dots vertical. Table 4-3 lists the specifications for the CRT.

Table 4-3 CRT Specifications

Characteristic	Specification
Screen Size	140 mm Diagonal
Deflection Method	Magnetic
Deflection Angles	Diagonal - 70 degrees
	Horizontal - 66 degrees
	Vertical - 45 degrees
Phosphor	P43 (Yellow-Green)
Heater	75 mA, 12 V (typical)

Control signals to drive the CRT come from the CRT/Recorder gate array on the control board. Table 4-4 lists the control signal specifications:

Table 4-4 Control Signal Specifications

Vertical Deflection	
Frequency	57.1 Hz
Period	17.5 ms
Blanking Time	1.5 ms
Vertical Sync	750 us (Active High)
Horizontal Deflection	
Frequency	16.0 kHz
Period	62.5 us
Blanking Time	11.7 us
Horizontal Sync	11.7 us (Active Low)
Video	
Dot Time	61 ns (Active Low)

Vertical Deflection

Vertical deflection is accomplished by running a linear current ramp through the vertical coil on the CRT yoke. The Vertical Sync (VS) signal from the CRT controller generates the vertical deflection for the CRT.

Horizontal Deflection

The Horizontal Sync (HS) and CRT bias voltages are generated when HS drives the flyback transformer, which provides supply voltages and horizontal deflection. Horizontal centering must be accomplished using the external magnets on the CRT yoke assembly. Horizontal width is adjusted with a series inductor, also built into the yoke assembly.

The following supply voltages are created for use in biasing the CRT:

+28 V	Video amplifier and Vertical retrace
-39 V	Intensity (adjustable)
300 V	Grid 2 bias
300 V	Focus (adjustable)
7.5 kV	Anode Voltage

Video

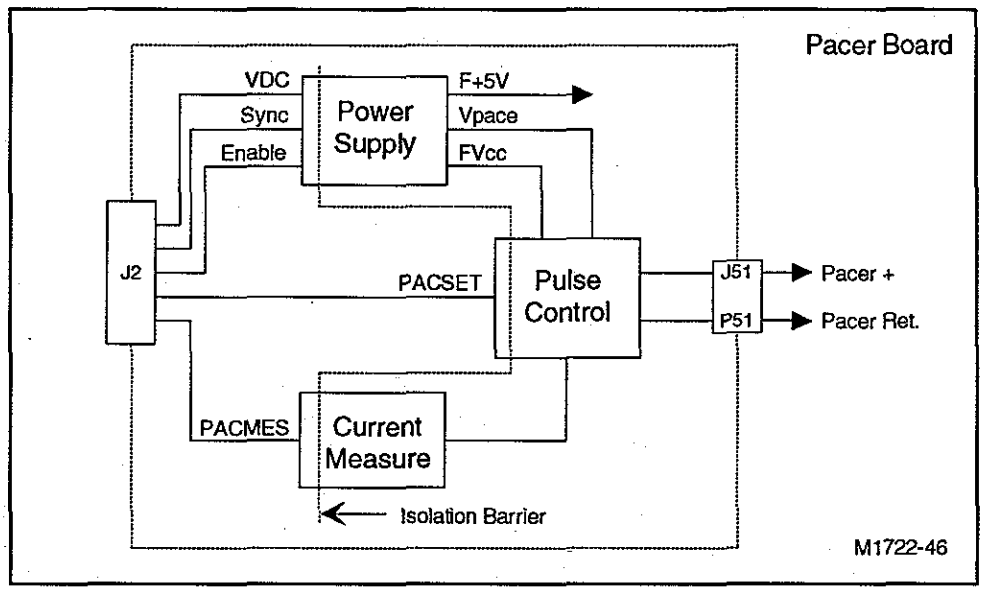
Two levels of video are presented to the CRT: full-bright and half-bright. Half-bright video is used for text, while full-bright video is used for ECG data. The beam is at full brightness when the video output to the CRT is 0 V, at half brightness when the video output is 4.3 V, and off when the video output is 28 V.

Pacer Board

The pacer consists of the circuits shown in Figure 4-8. The pacer board generates pacer output to these specifications

Current Pulse	20 ms +0% -25%
Amplitude	30 mA to 200 mA, 30 mA to 50 mA: ±5 mA, 50 mA to 200 mA: ±10%
Rate	40 to 180 pulses-per-minute ±1% at each setting

Figure 4-8



Pacer Block Diagram

Power Supply

An isolated supply on the pacer board generates 5 and 12 V power (F+5V and FVcc, respectively) to run the pacer electronics, and the 120 V pacer voltage (Vpace).

Pulse Control

Pace pulse amplitude is set by a pulse width modulated signal from the System gate array. The duty cycle for the PWM signal is 13.5% to 90%, corresponding to a pulse amplitude from 30 mA to 200 mA respectively.

The pulse train from the System gate array is 20 ms long. When the pulse train starts, it begins the current pulse. When the pulse train ends, the current pulse will end.

Pacer Current

Pacer current is measured and routed back to an A/D converter (internal to the Defibrillator processor). Then, delivered pacer current can be compared to the expected set current.

Patient Isolation

The pacer is a patient connected device, therefore adequate patient isolation must exist for pacer circuitry. A high voltage isolation barrier is formed by a power transformer in the power supply, and opto-couplers in the pulse control and current measuring circuits.

SpO_2 Board

The arterial oxygen saturation measurement (SpO_2) is based upon the principle of pulse oximetry, whereby arterial blood flow is detected optically though the tissue. As the blood becomes more heavily oxygenated the transmittance of red light increases. An algorithm comparing the transmittance of red and infra-red light provides an indication of oxygen saturation. The pulse oximeter circuit design eliminates the effects of absorption from tissue, bone, and venous blood by isolating the pulsatile component of the signal.

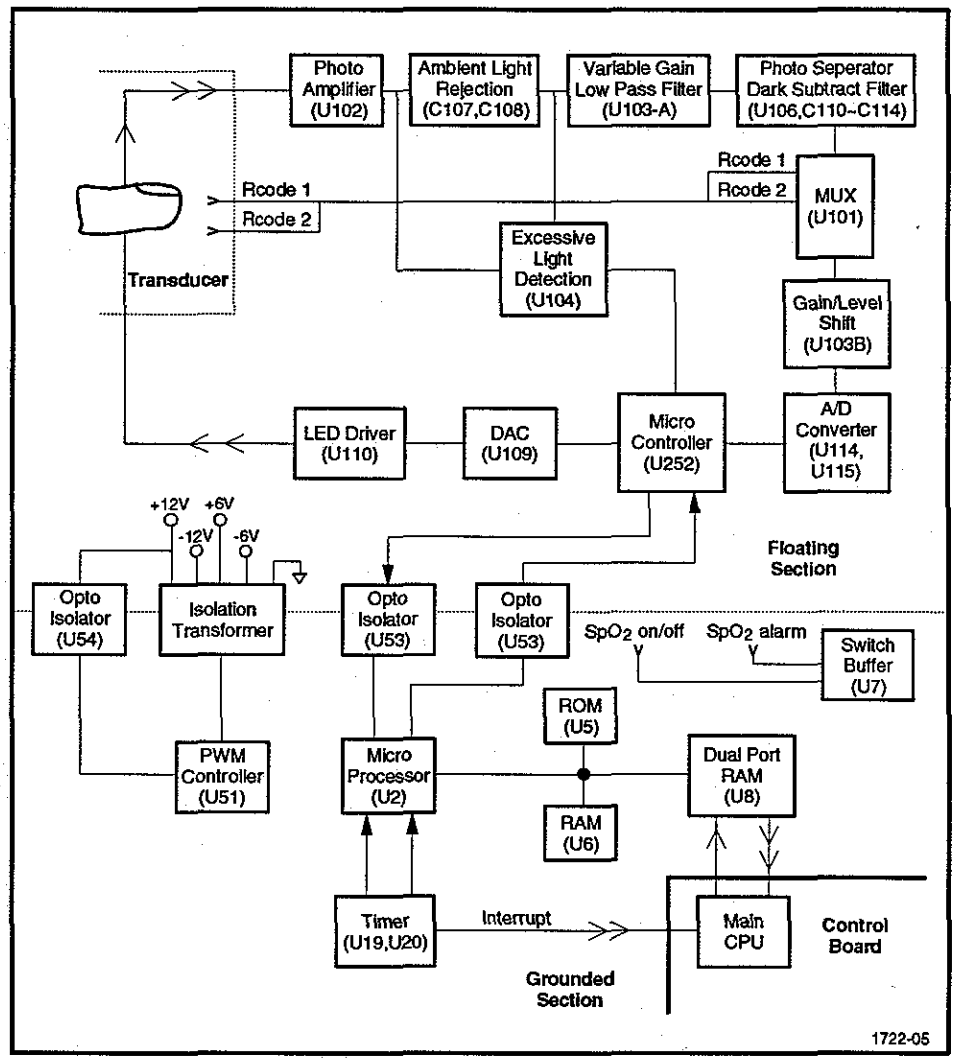
To measure the SpO_2 level an adaptor is placed on the patient. The adaptor holds two LEDs. The LEDs emit red and infra-red light against one side of the patient's finger (the nose or toe are other sites sometimes used). The adaptor holds a photo diode along the opposite side of the patient's finger. The photo diode is able to register small changes in the transmittance of light through the finger. The adaptor containing the LEDs and the photo diode is referred to as the SpO_2 sensor. The sensor is connected to the device via a cable and a connector.

The output from the sensor goes directly to the pulse oximeter parameter board (SpO_2 board). The SpO_2 board is located next to the CodeMaster CRT and is connected to the main CodeMaster control board via the option connector slot.

The SpO_2 board is divided into two distinct circuits - electrically floating and electrically grounded. These circuits are connected by two high voltage optocouplers for data transfer, and a power transformer for power transfer to the floating circuit.

The hardware design is summarized in the block diagram in Figure 4-9.

Figure 4-9



SpO_2 Board Block Diagram

Floating Section

The function of the floating section is two fold. First, the floating section enables accurate reading of light transmittance by removing noise and compensating for ambient light in the pulse train. Second, the floating section drives the red and infra-red LEDs in the transducer cable.

The LEDs are driven and the photo diode signal is sampled in four discrete phases:

1 Dark phase - During this phase neither red nor infra-red LEDs are lit and ambient light is measured.

2 Red phase - In the red phase the red LED is lit and the transmittance of the light through the finger is measured.

3 Infra-red phase - In the infra-red phase the infra-red LED is lit, and transmittance measured.

4 Pleth Phase - During this phase the infra-red LED is lit, and transmittance measured. This signal is used to drive the pulse indicator bar on the CodeMaster display.

Consecutive frames of these four phases are repeated 375 times per second. Both the lighting of the LEDs and the sampling of the signal from the photo diode is controlled by the microcontroller (U252).

Photo Amplifier

The photo amplifier (U102) converts current (output from the photo diode) to voltage. Low pass filtering for electrosurgical unit (ESU) filtering and noise reduction is also done in this stage.

Excessive Light Detection

A comparator (U104) monitors the output of the photo amplifier, checking for excessive light. Excessive light could cause amplifiers to operate in a non-linear range, giving erroneous readings.

Ambient Light Rejection

A two-pole high pass filter (C107, C108) rejects signals from ambient light.

Amplification

The op amp, U103A, is used as a variable gain amplifier. It amplifies the detected light signal to an optimal amplitude for the A/D converter. U103B applies additional gain and level shifting, centering the signal for the A/D converter.

Phase Separation - Dark Subtract Filter

A series of switched low pass filters (U106, C110 - C114) are used to separate the four phases of light (dark, red, infra-red, and pleth). The sequence of operation is software controlled. The four phase sequence is described as follows:

1 ***Dark phase*** The switch governing the dark capacitor (C110, C111) is closed. Switches governing the red, infra-red, and pleth capacitors (C112, C113, and

C114 respectively) are open. The dark capacitor is charged by the pulse resulting from the ambient light reading.

2 ***Red phase*** The switch governing the "Red" capacitor is closed. All other switches are open. Capacitor "Red" is charged by the pulse resulting from the red LED reading. The pulse received by amplifier U103B is equivalent to the value of (ambient light + red light) minus (ambient light).

3 ***Infra-red phase*** As (2) above, but using the "Infra-Red" capacitor.

4 ***Pleth phase*** As (3) above.

Multiplexer

A multiplexer (U101) is used to switch signals into the A/D converter. The signals are:

1 Received light signal.

2 Rcode1.

3 Rcode2.

Rcode1 and Rcode2 are resistors in the transducer. The voltage across these resistors is measured to determine that the transducer is properly connected, and the type of transducer connected.

A/D Converter

A sixteen bit successive approximation A/D converter is formed from a 16 bit DAC (U114), a comparator (U115), and a uP controller (U252).

LED Drivers

The LEDs are driven by a controlled current source (U110). The two functions provided by the LED driver are:

1 The LEDs must be lit in their correct sequence, to produce the four phases of the pulse frame.

2 The LEDs must be lit to an intensity that optimizes the signal to noise ratio of the received light signal.

An 8 bit DAC (U109) controls the LED driver (U110), using positive and negative pulses of 0 - 125mA, which trigger the red and infra-red LEDs respectively. The intensity of illumination is determined by the current of this triggering pulse.

Grounded Section

The grounded section of the SpO_2 board is completely digital. It is essentially a dedicated microcomputer, and among other tasks, performs the following:

1 Communicates with the floating section through the two opto-isolators.

2 Calculation of the SpO_2 saturation percentage and pulse rate.

3 Processes any error conditions (cable off, light interference, etc.)

4 Communicates with the main CPU board in CodeMaster via the option slot on the control board.

Dedicated timer circuits control the timing of events. In addition, the signals from the front panel keys SpO_2 ON and SpO_2 ALARM are routed through the SpO_2 board to the Control board.

Microprocessor System

The processor is a Hitachi 6303, using external RAM and ROM. The processor runs on a 2mS cycle, which is controlled by the timer circuits (U19 and U20). Once every 20mS the processor writes data to the Dual Port Ram (U8).

Communication

An interrupt is generated every 20mS, indicating to the Control that board data is available to be read. At this time, the switch buffer (U7) is read to check for any key presses, and SpO_2 data (SpO_2%, PR, error conditions) are read from the dual port RAM.

Power Supply

The power supply is designed to provide isolated power to the floating circuitry. The circuit is a fly back topology, with feedback though an opto isolator (U54) to control the pulse with modulator. The transformer includes taps to generate ±12V and ±6V. In addition, linear regulators exist on the floating side to generate +5V and -5.2V.

Patient Isolation

To ensure the safety of the patient the applied part is isolated from ground by optocouplers and a transformer. In addition, a mylar shield is used to isolate the floating circuitry from the CRT frame.

Recorder Interface Board

The Recorder Interface board provides power and control signals from the CRT/ Recorder gate array to the printhead and motor.

The printhead control signals pass through the board to the printhead. These signals provide the data, clock (4 MHz), latch, and strobe for the printhead. Other signals provide status of the printhead to the gate array such as printhead temperature and resistance, which are required for print quality. An optical sensor in the recorder provides the status of the recorder door and recorder paper (if the door is open or the paper is out the CHECK RECORDER message appears on the monitor).

Keypanel Boards

The main keypanel board and the pacer keypanel board contain the push-button switches and LED indicators that provide the hardware user interface. The Energy Select switch connects to the main keypanel board.

Defibrillator-Pacer Patient Connections

The defibrillator provides support for the following methods of delivering defibrillation or pacing energies to the patient:

- Standard External Paddles
- Internal Paddles
- External Adhesive Pads

Standard External Paddles

The Standard External Paddle Set combines Adult and Pediatric defibrillation electrode surfaces in one paddle design. The Sternum paddle has a Paddle Contact Indicator (PCI, standard on the XL+, optional on the XL), and a Shock button. The Apex paddle has the CHARGE INITIATION button, a CHARGE DONE LED, and a Shock button.

The defibrillator determines paddle type by measuring the voltage on the CHDONE control line. The voltage range for a valid External Paddle Set is 0.5 - 3.0 volts. The Shock switches pull their respective lines (nDischarge Sternum, nDischarge Apex) to logic ground when pressed. Single fault tolerance is maintained throughout the discharge control path for operator safety. The Charge switch pulls the nCharge line low when pressed.

Internal Paddles

The Internal Paddles are connected to the defibrillator using a connector on the internal paddles adaptor cable. There are no shock control switches on the Internal Paddles themselves. The defibrillator is discharged by pressing two shock buttons located on the defibrillator connector housing.

The defibrillator determines paddle type by measuring the voltage on the CHDONE control line. The voltage for a valid Internal Paddle Set is less than 0.5 Volts.

External Adhesive Pads

The External Adhesive Pads are connected to the defibrillator using an auxiliary connector on the pads adaptor cable. External Pacing and Defibrillation can be performed through this connection. The defibrillator is discharged by pressing two shock buttons located on the defibrillator connector housing.

The defibrillator determines paddle type by measuring the voltage on the CHDONE control line. The voltage range for a valid external adhesive Pads adaptor is 3.0 - 4.0 V.